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Address:
Astronomical Observatory, Odessa State University
T.G.Shevchenko Park, Odessa 270014 UKRAINE
Tel., Fax: + 7 + 0482 + 22 84 42
Tlx: 232337 CEFEY
E-mail: root@astro.odessa.ua (Internet)

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FOREWORD

In 1993 a decade has passed since an outstanding scientist astronomer Vladimir Platonovich Tsessevich died. And we, his disciples and collaborators on the development of astronomy in Odessa, decided to organize a Conference in his memory. To his and many well-known scientist of the former Soviet Union were invited, those with whom we not only didn't lose touch but also kept close links as our Head of Astronomical Chair and the Director of Astronomical Observatory at the Odessa State University after I. I. Mechnikov, the founder of "Izvestija Astronomicheskoi Obserwatorii", a corresponding member of the Academy of Sciences of the Ukraine, Professor V. P. Tsessevich had bequeathed us.

The present conference of 1993 happened to be both memorial and traditional. Within the last score of years this is already the third scientific conference of variable stars'investigators to have been held in Odessa. The two preceding took place in 1980 and 1987, the first being held on the initiative of V. P. Tsessevich. In 1984, in a year after V. P. Tsessevich death, the all-Union Conference of young scientists was held in his memory. The 1987 Conference was very representative and also in memory of an outstanding scholar V. P. Tsessevich who had studied nature of more than 500 variable stars of various types and described his findings in more than 600 scientific notices and papers.

The Scientific Conference "Modern problems of astrophysics" was held from 13 through 18 September 1993 under the aegis of the Astronomical Observatory of Odessa State University, Odessa Astronomical Society, Ukrainian Astronomical Association, International Astronomical Society in Moscow. 153 scientists from 6 countries of the Commonwealth of Independent States as well as astronomers from Canada, Estonia, Finland, France, Germany, Hungary, Italy, the Netherlands, Poland, Slovakia, UK, USA contributed to the conference. The conference work was carried out at the morning plenary sessions and at the afternoon 4 section sittings. There worked the following sections: on physical variables, close binary stars, their atmospheres, variability of radio-sources and on the instrumental base of the observatory.

All in all 15 review research reports and 109 section informations were carried out. In many reports, the contribution made by V. P. Tsessevich to the investigation of variability in stars of various types was accentuated as well as his worthy lecturer's tenure and organizer's work on creating the Odessa Variable Star Investigators' School, his inexhaustible enthusiasm in popularizing astronomical knowledge by virtue of lectures and books. All 93 reports and informations delivered at the Conference and sent by authors for press have been published in original wording in the present volume subdivided into two parts. The contributions are published in the alphabetical order of the authors within sections, with an exception for short notes which are located into blank spaces. The Editor expresses gratitude to all the authors for the materials sent and hopes for further fruitful cooperation.

V. G. Karetnikov

CLOSE BINARY SYSTEMS ON LATE EVOLUTIONARY STAGES

A. M. Cherepashchuk
Sternberg State Astronomical Institute, Moscow State University
Universitetskij Prospect 13, Moscow 119899 Russia
E-mail: cher@sai.msk.su

ABSTRACT. Observational and theoretical progress in investigations of close binary stars allow to understand the nature and evolution of many types of close binary systems containing peculiar components: Wolf-Rayet stars, white dwarfs neutron stars and black holes. Catalogue of evolved close binary systems of stars after first mass exchanges has been published by our group in 1989. Second edition of this catalogue is now in preparation and will be published in 1995 by Gordon & Breach.

Key words: Stars: Binaries, Catalogs.

Let us consider modern evolutionary scenario for high mass close binary systems (HMCBS) developed in the pioneer works by Paczyński (1973), Tutukov & Yungelson (1973), Van den Heuvel (1976), Kornilov & Lipunov (1983).

Many of theoretical predictions made by this scenario have been confirmed by the observations. There are also some new observational data which stimulate further development of the theory.

Well known scheme of the evolution of the stars in high mass ($m_1 + m_2 > 30M_\odot$) close binary system can be presented as follow: $OB_1 + OB_2 \rightarrow WR_1 + OB'_2 \rightarrow$ explosion as a supernova of WR_1 star $+ OB'_2 \rightarrow$ relativistic object $(C) + OB'_2 \rightarrow C + WR_2$ (or single Thorne – Zytkow object) $\rightarrow C+$ explosion as a supernova of WR_2 star $\rightarrow$ two relativistic objects.

For the majority of HMCBS ($\approx 90\%$), according to Yungelson & Massevich (1982), primary, more massive components will fill their Roche Lobe & begin transfer matter to their companions not before they have terminated core-hydrogen burning (so-called "Case B" evolution according to Kippenhahn & Weigert (1967)). In such a case the primary more massive star OB_1 will transfer practically all of its hydrogen envelope to its companion and only its helium core will be left after the transfer. This helium core, according to Paczyński (1973) can be identified with Wolf-Rayet (WR) star.

On the first stage HMCBS consists of two main sequence stars OB_1 (more massive) and OB_2. For further considerations we need some information about the initial mass ratio $q = m_1/m_2$ for the components. If q is close to unity it seems rather probable that the conservative mass exchange occurs in the binary system because the times of thermal relaxation for both stars are close to each other. For the values of q which are quite different from the unity conservative mass exchange in the binary system seems to have low probability, and mass loss and angular momentum loss from the system occurs. According to statistical investigations (see e.g. Svechnikov 1969), the value of q in average is close to unity (also there is different point of view by Iben & Tutukov 1984). Here we will consider the conservative case of evolution of HMCBS.

Let us consider the case of q close to unity. The time of nuclear evolution of the star on the core hydrogen burning stage (e.g. Yungelson & Massevich 1982)

$$\lg \frac{t}{1 \text{ year}} = 9.9 - 3.8 \lg \frac{M}{M_\odot} + \lg^2 \frac{M}{M_\odot} \quad (1)$$

and for the value of mass of the star $M \approx 30M_\odot$ is equal to $\approx 3 \cdot 10^6$ years. More massive star OB_1 in HMCBS will evolve more rapidly and fills its Roche Lobe. Let us suppose that this filling corresponds to the "case B" of evolution. The first mass exchange begin in the binary system. The star OB_1 will transfer its mass through inner Lagrangian point onto the OB_2 star. This matter is accreted by the OB_2 star because the times of thermal relaxation for both stars in the system are comparable ($q \approx 1$). Process of the first mass exchange is very rapid (corresponding time scale is thermal but not nuclear), because, in particular, separation a between the components of the system in the conservative case of mass exchange is decreasing according to the formula:

$$a = \frac{const}{m_1^2 m_2^2} \quad (2)$$

Under the condition of $m_1 + m_2 = const$ the minimum of the value of a is reached when $m_1 = m_2$. Therefore the value of a is decreasing when more massive star OB_1 transfers its mass onto less massive star OB_2 which stimulates the process of mass exchange in close binary system. The duration of the first mass exchange (in the case of Ledoux criterion) is

$$t_k \approx \frac{10^{6.3}}{(m_1/m_\odot)^2} \text{ years.} \quad (3)$$

The primary component OB_1 for the time $\approx 10^4$ years will lose up to 70-90% of its hydrogen envelope, which will be accreted by OB_2 star. The OB_2' companion is formed in the HMCBS as a result of such primary mass exchange.

All the close binary systems after first mass exchange are called as evolved close binary systems.

Observational appearances of all known types of evolved close binary systems (high mass and low mass) are summarized in our Catalogue of close binary stars on late evolutionary stages (Aslanov et al. 1989).

The Catalogue contains the parameters of a wide number of close binary systems (CBS) at late evolutionary stages. The general list of the stars chosen for the Catalogue is given in the Introduction. Description of main evolutionary stages of CBS is given in Chapter 1. Chapter 2 contains the parameters of massive CBS: W Ser type stars; WR+OB systems, containing of a WR star and a massive star of early spectral class; CBS including an OB star and presumably a relativistic object (so called X-ray quiet binaries). Massive CBS at X-ray stage are given also in section 4. These are transient X-ray sources (CBS containing a Be star and a neutron star), and stationary X-ray binaries (CBS containing a massive OB star and a neutron star or black hole). The parameters of CBS containing of WR star and presumably a relativistic object are compiled in section 5.

Chapter 3 is dedicated to low-mass CBS containing a relativistic object coupled with a "normal" star. These are low mass transient X-ray sources, stationary X-ray sources in the Galactic bulge and Sco X-1 type stars, and X-ray bursters. The list of bursters in globular clusters is given too.

The wide class of cataclysmic variables (CV) and related object is divided in Chapter 4 into subclasses according to their physical parameters (specifically by their magnetic fields). Precataclysmic variables are described in section 1. Novae, recurrent novae, dwarf novae systems with determined or assumed orbital periods are collected in Table 13, and double white dwarfs in Table 14 (section 2).

The symbiotic stars with determined or assumed orbital periods are compiled in section 3.

DQ Her stars (intermediate polars) and AM Her stars (polars) are collected in section 4.

The parameters of radiopulsars - the members of binary systems are given in Chapter 5.

Second Edition of this Catalogue is now in preparation in our group and will be published in 1995 by Gordon & Breach.

It should be stressed that up to now reliable determinations of masses for 10 pulsars in binary systems have been carried out (6 in X-ray binaries and 4 in binary radiopulsars). For all 10 pulsars the value of mass is less than $3M_\odot$ - theoretical upper limit predicted for the mass of neutron star by Einstein General Relativity. On the other hand, there are 5 reliable estimates of the masses of black hole candidates in X-ray binary systems (Cyg X-1, LMC X-3, A 0620-00, V404 Cyg, XN Mus). For all these massive ($m_x > 5M_\odot$) compact X-ray sources pulsar phenomenon was not detected. Therefore X-ray sources in binary systems are different from each other not only by masses but also by their observational appearances, in accordance with Einstein General Relativity. This fact is very significant and has a great importance for the testing of Einstein General Relativity in strong gravitational fields.

All these facts demonstrate a big progress which has been achieved up to now after pioneer works made by V.P.Tsessevich in the investigation of close binary systems.

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UBVRI POLARIMETRY OF CLOSE BINARY SYSTEM V448 Cyg

N. M. Shakhovskoy[1], G. V. Volkova[2], Yu. L. Manilov[2], N. H. Minikulov[1]
[1] Crimean Astrophysical Observatory, Nauchny 334413 Crimea, Ukraine
E-mail: shakh@crao.crimea.ua
[2] Astronomical Observatory, Odessa State University,
T.G.Shevchenko Park, Odessa 270014 Ukraine, E-mail: root@astro.odessa.ua

ABSTRACT. Analysis of the polarimetric measurements of the eclipsing binary system V448 Cyg in wide UBVRI filters has shown the presence of the following components of the polarization: a) interstellar; b) constant intrinsic polarization with a flat spectrum; c) phase-dependent contribution, the amplitude of which decreases with wavelength. Constant component is possibly caused by an extended disk-like optically thin refracting envelope; the variable one may be caused by relatively dense condensations near the Lagrangian points in a binary. By analyzing the Fourier harmonics, the inclination angle is found to be $i = 82°$. The orbital plane of the system is inclined in respect to the Galaxy plane at an angle 70°. Mass of the extended envelope is estimated to be $1.5 \cdot 10^{-8}\ M_\odot$ with a mass loss rate $8.6 \cdot 10^{-7}\ M_\odot$/yr.

Key words: Stars: binaries: close, eclipsing; circumstellar matter; polarization.

ON COLLISION OF SECONDARY NUCLEI OF COMET P/SHOEMAKER-LEVI 9 (1993E) WITH JUPITER

K. I. Churyumov, V. G. Kruchinenko
Astronomical observatory, Kiev University
ul. Observatornaya 3, Kiev 252003 Ukraine
E-mail: aoku@gluk.apc.org

ABSTRACT. In July 1994 the comet P/Shoemaker-Levi which in July 1992 split in the Roche lobe of Jupiter onto 21 fragments, then collided with Jupiter at the altitude near -45^o. The consequences of this collision in the form of outbursts of brightness of the Jupiter satellites/ emergence of new structures in the cloud layer of Jupiter (type of the Great Red Spot), generated of radiowaves and appearance of aurora, were observed at numerous world observatories, as well as from space probes. Since the moment of the split of comet P/Biela in 1846 onto two comets, astronomers have been already observing the 24th comets whose primary nucleus split onto secondary nuclei. The mechanism of destruction of the comet Shoemaker-Levi 9 was the tidal force of Jupiter which split the parental nucleus onto 21 icy pieces along one straight line. Prognosis of outbursts of brightness of Jupiter's satellites as a result of the light outburst in the atmosphere of the planet in the course of collision of the comet Shoemaker-Levi 9 with the latter is given. The Astronomical Observatory of Kiev University scientific program of observations of the collision of the comet Shoemaker-Levi with Jupiter is also presented.

Key words: Comet; capture; collision; Jupiter; bolide; satellite

Introduction

In July 1994 astronomers for the first time in the history of science will observe the unique event - impact of the 21st secondary nucleus of comet P/Shoemaker-Levi 9 (SL9) with giant planet Jupiter. Though the fragments of the split comet will fall on the night side of the planet, great energy generated as a result of colliding cometary nuclei with one another with Jupiter's atmosphere will yield a series of secondary events which will be registered at the ground-based observatories and from space probes.

Such secondary events may be short-period increases in the Jupiter satellites' brightnesses reflecting the light outburst of the impact, emergence of new structures in the cloudy atmosphere of Jupiter (type of curls similar to the Great Red Spot) formation of a ring around Jupiter, appearance of aurora in Jupiter's magneto sphere, generation of radio waves and other effects.

Statistics of Cometary Nuclei Splitting

The flight of space apparatus near the comet Halley nucleus on March 1986 is a bright evidence of the conception of the cometary ice origins of cometary nuclei: the content of water H_2O in the nucleus of P/Halley was 80 % from the total nucleus mass (Moroz 1987), Therefore, as has been expected earlier, cometary nuclei appeared mechanically low strength tensile bodies in the Solar System, This fact was known to astronomers at last since the moment of splitting of the primary nucleus of comet P/Biela in 1846 onto 2 secondary nuclei A and B. with then were observed in 1852 in the form of two comets with tails moving around close orbits. Since then nuclei splitting onto secondary fragments has been observed in other 23 comets.

Catalogs of the split comets were composed by Konopleva (1967), Pittich (1972), Golubev (1975), Sekanina (1982). The more detailed catalogue of the split comets is given in the work by Sekanina (1982). To the list of comets given by Sekanina, three more comets should be added. The Table contains the list of comets where splitting of nuclei was observed: 1 column - names of comets, 2 - a number of secondary nuclei N, the splitting moment τ_s, the heliocentric distance r_s and distance from the ecliptic plane z_s at the splitting moment, the time interval between moment of comet perihelion passage and the moment of splitting $\tau_s - T$.

Statistics of the split comets has led to the following results:

1. velocity of fragments escaping is linked with the heliocentric distance by the formula (Sekanina 1982)

$$V = B \cdot r^{-b} \tag{1}$$

where $B = 0.70 \pm 0.09$ m/s and $b = 0.57 \pm 0.10$;

2. a tendency of the split of comets near the ecliptic plane is observed, tough there is no clear dependency, that might be explained by observation selection;

3. Physical mechanisms that lead to split of cometary nuclei may be tidal forces, chemical outburst of the nucleus, collision with meteor bodies, as well as centrifugal forces of the fast rotating nucleus. The influence of tidal forces is undoubted in the case of comets that had closely approached the Sun (comets 1882 II and 1965 VIII) and Jupiter (comets 1889 V and 1993e). Especially visible the action of tidal forces can be traced in the comet SL9, whose 21 secondary nuclei in the Roche lobe stretched along the straight line.

Discovery of the comet P/Shoemaker-Levi 9

The comet SL9 was discovered by Caroline and Gene Shoemaker and David Levi on the film obtained March 18, 1993 with the help of the 0.46-meter Schmidt telescope at the Palomar observatory. The object was located on the sky nearJupiter and was strong elongated in the east-west direction. As turned out, this elongation could be explained by the existence of 21st secondary nuclei were formed as result of the passage of the parental cometary nucleus inside the Roche lobe of Jupiter on July 1992. The nuclei were moving along similar orbits around Jupiter, and they were strong elongated ellipses. The rotation period of the 21-multiple comet around Jupiter was 2 years. As calculations showed, the next passage of the comet fragments through perijovion will occur during July 16-22; perijovion distance being less than the radius of the planet, from which it follows that the secondary nuclei will collide with Jupiter. Collision will occur at the latitude -45^o on the night side of the latter. During collision of the fragments with the planet energy from 10^{28} to 10^{31} ergs will be yielded that can be compared on the order with the energy of a solar outburst and $10^6 - 10^7$ times exceeds the energy which had yielded during the fall of the Tunguska meteorite in Siberia in 1908.

The secondary nuclei of the comet SL9 were designated by the Latin letters from A to W. The brightest nucleus is Q. The integral magnitude of the comet SL9 in 1883 according to the ground observations was $m_1 = 13.5 - 14^m$. Around each nucleus a dust coma and dust tails were observed comprising particles of micron sizes, submillimeter - size and meter - size boulders.

According to calculations (ESO Press Release 10/94, 1994) the first nucleus A will collide with Jupiter July 16, 1994 at 18:00 UT. The second nucleus B will fall in the morning July 17, 1994 at 03:00 ut. The nuclei A and B are rather small in size. And the first of the large nuclei E will collide with Jupiter July 17, 1994 at 15:00 Ut. The brightest nucleus Q (according to observations from the Hubble telescope HST it also split onto two nuclei) will fall July 20, 1994 at 20:00 UT. The last nucleus of the "comet train" W will collide with the planet July 22, 1994 at 8:20 UT. Error in these moments is $\pm 45^m$ tough near these events the processing of all obtained data will allow to improve them up to $\pm 15^m$.

Entry of large bodies into Jupiter's atmosphere

A problem of a separate large piece of nucleus of Shoemaker- Levy comet passing through Jupiter atmosphere is considered. It is assumed that: initial size (diameter) of a spherical body is 1 km, mean body density is 0.8 g/cm^3, velocity of entry is 60 km/s, zenith angle of entry is 45^o. Atmosphere density distribution with height $\rho(H) = \rho_0 \exp(-H/H^*)$, where $\rho_0 = 10^{-4}$ g/cm^3 at conventional height $H = 0$ (corresponds to atmospheric pressure of 0.5 atm), height of homogeneous atmosphere $H^* = 20$ km.

Shock wave is formed at height 400 km. Intensity of bolide radiation (of shock wave radiation) in integral light (by $T = 20,000$ K after Stefan's law) equals to $\approx 10^{24}$ ergs/s and during 10 s of the flight it will constitute quantity of order 10^{-3} as related to solar radiation at the distance of satellites Io or Europe.

Because of quick dissociation of sublimated parent molecules in near to the nucleus area of the comet (temperature here is 2600 - 3000 K), radiation in lines of oxygen and hydrogen is likely to be dominating one in visible region of the spectrum. Cyan is unlikely to contribute greatly to radiation, either.

The body is unlikely to reach the height of maximum deceleration $H_* = -100$ km, where the estimate of the velocity equals to 35 km/s, deceleration is - 27 km/s , because aerodynamic loads are too high there - 10^{10} N/m^2.

Explosion and flash of brightness should occur at aerodynamic pressure $10^7 - 10^8$ N/m^2, that is at about 100 km higher. We suggest that luminescence of the flash is due to stone fragments having mass of 0.1 - 1.0 g and density of 3 g/cm^3. Total mass of these fragments is assumed to constitute 10 per cent of comet nucleus mass which is left by the moment of flash, i.e. $\approx 10^{13}$ g. The short term flash of this kind ($\approx 10^{-2}$ s) can increase the satellites Io or Europe brightness in 0.2^m to 0.8^m.

Plans to Study the Event

Astronomical observatory of the Kiev University plans to realize the following program:

1. Patrol observations of the P/Shoemaker-Levy 9 (May-July 1994 near the Jupiter from the observational station of Kiev Astronomical observatory by means of telescopes AZT-8 (D=70 cm) and AZT-14 (D=50 cm), image converter tube and TV-equipment with narrow-band interference and polarimetric cometary filters in order to determine the parameters of gas and dust production rates from the secondary nuclei of the comet before the impact process. Attempt of TV-spectroscopy of the cometary nuclei with application of such telescopes as the 6-meter reflector of Special AO, 2.6-meter Shine reflector of Crimea AO and 2-m Zeiss reflector of Shemakha AO.

2. TV-observations of the equatorial zone of the Jupiter before and after the impact in order to find out the structure changes in the cloudy layer of the equatorial zone and in the southern hemisphere (down to -45°.): a) search for new vortex-like (type of the GRS) and other structures in the equatorial zone; b) search for a dark equatorial band that could be a shadow of the new dust Jupiter ring formed from the dust component of the secondary nuclei broken down in the Roche lobe; c) polarimetric observations of the equatorial and south tropical Jupiter zones in order to evaluate the mass of the dust substance originated from the secondary nuclei of the comet. d) photoelectric observations of the Jupiter satellites Europe and Ganymede about the moment of impact in accordance with the data of IJW/Aurora, v. 4, n. 4, p. 2 (1993).

3. Computer simulation of interaction of cometary plasma, originated from impact of cometary particles with the particles of planetary atmosphere, with the Jupiter magnetosphere.

4. Numerical simulation of the "fireballs" resulted from impact of the secondary cometary nuclei with the Jupiter atmosphere.

5. Investigation of the natural oscillations of the Jupiter magnetosphere. International comet SL9-Jupiter Watch: It is generally expected that nearly every observatory in the world will be observing events associated with the impact. These observatories will include several Earth-orbiting telescopes (Hub-

Table 1. The splitting comets

Comet/Name	N	τ_s	r_s	z_s	$\tau_s - T$
P/Biela	A-B	1840.05.25	3.59	+0.04	-2088
Liais (1860 I)	A-B	1859.09.18	2.49	+2.17	- 152
Great September Comet (1882 II)	A-D	1882.09.17	0.017	+0.003	+0.83
Sawerthal (1888 I)	A-B	1888.03.02	0.76	-0.28	-14.9
Davidson (1889 IV)	A-B	1889.07.30	1.06	0.00	+ 11
P/Brooks 2 (1889 V)	A-E	1886.07.21	5.38	+0.09	-1168
P/Giacobini (1898 V)	A-B	1896.04.24	2.36	+0.35	- 187
Swift (1899 I)	A-C	1899.04.25	0.48	+0.26	+12.09
Kopf (1905 IV)	A-B	1906.03.25	3.38	+0.04	+54
Campbell (1914 VI)	A-B	1914.08.25	0.82	-0.59	+20
Mellish (1915 II)	A-E	1915.03.23	2.09	+0.70	-116.6
P/Taylor (1916 I)	A-B	1915.12.08	1.65	-0.27	-53.4
Whipple-Fedtke-Tevzadze (1943 I)	A-B	1943.03.09	1.43	+0.44	+30.8
Southern Comet	A-B	1947.11.30	0.15	+0.07	-2.05
Honda (1955 V)	A-B	1953.07	8.2	-3.5	-740
Wirtanen (1957 VI)	A-B	1954.09.10	9.25	-4.97	-1087
Ikeya-Seki (1965 VIII)	A-C	1965.10.21	0.008	+0.005	+0.016
Wild (1968 III)	A-B	1968.08.03	2.92	+1.33	+125
Tago-Sato-Kosaka (1969 IX)	A-B	1970.02.09	1.20	+0.20	+50
Kohoutek (1970 III)	A-B	1970.04.29	1.79	+0.98	+38.9
West (1976 VI)	A-D	1976.02.27	0.22	+0.09	+2.27
Wilson (1987 VII)	A-B	1987			
P/Chernykh (1991o)	A-B	1991			
P/Shoemaker-Levi (1993e)	A-W	1992.07.09	5.2		

ble Space Telescope, International Ultraviolet Explorer, Extreme Ultraviolet Explorer) and several interplanetary spacecraft (Galileo, Clementine, and possibly others). Most observatories are setting aside time and resources but delaying detailed planning until the last possible minute in order to optimize their observations based on the latest theoretical predictions and the latest observations of the cometary properties.

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INTERRELATIONS BETWEEN ECLIPSING BINARY SYSTEMS OF VARIOUS TYPES AT THE STAGE OF THE FIRST MASS EXCHANGE

V. G. Karetnikov
Astronomical Observatory, Odessa State University,
T.G.Shevchenko Park, Odessa 270014 Ukraine
E-mail: root@astro.odessa.ua

ABSTRACT. Topics of the empirical study of the evolutionary directions of the eclipsing binary stars of different types are reviewed. It was shown that close binary systems at the first stage of the mass exchange may be distinguished into 3 evolutionary groups, the members of which may evolve from one group to another. This suggestion is justified by the analysis of the dependencies of the main characteristics of the stellar components in binaries and by the location of them at the proposed diagram of the degrees of filling the Roche Lobe.

Key words: Stars: binaries: close, eclipsing; circumstellar matter.

1. Introduction

The stars of binary systems throughout their evolution change the physical and chemical state of their entrails which results in the general characteristics change in the stars. These variations may be expected to tend to the stellar separation into groups from evolutionary status whereas finding relations between the groups enables us to study the laws of binary stellar evolution. With a great variety of absolute characteristics for binary systems, in contrast to single stars, in those there are restrictions of importance caused by the presence of equipotential surfaces, inner critical surfaces, above all – Roche lobes. These can play a part of a lacking criterion permitting to determine evolutionary state of a binary.

Let us consider the problem quoting eclipsing binaries being at the stage of the first matter exchange. We shall refer to these close eclipsing system classified by Svechnikov (1986) as detached in the main sequence (MS– systems), semidetached stars (SD– systems), detached pairs with a subgiant (SD– systems), contact systems of early-type stars (CE– systems) and of W UMa–type (CW– systems), detached stars similar to W UMa-type ($SimCW$– systems) and pairs of AR Lac-type (AR– systems) with rarely are referred to RS CVn–type. Many investigations doubt the reality of DS– system among the above types of binary stars (Budding 1985). It is not clear either whether AR-systems may be attributed to the stage of the first matter exchange.

The investigation of properties of the stars referred to the above types has shown them to consist of either the stars of the main sequence (MS–, CE–, CW–, $SimCW$– systems) or are stars of the main sequence and one subgiant–star (SD–, DS– systems) or the two subgiant stars (AR– systems). Since the stars of subgiant type have evolved earlier than those of the main sequence, whereas masses in stars of AR-systems are low and these evolve very slowly one can affirm that the separation of the above types of binaries into three above mentioned groups is of an evolutionary status of the binaries in the groups and examine their relations and transitions inside and between the groups, above all, in the first group of the system of binary stars.

The evolutionary arrangement of different types of eclipsing binary stars can be carried out from these considerations. As is shown in the estimates of evolutionary tracks for the stars, the latter increase their radii R in virtue of hydrogen burning in the core, variations occurring in effective temperature T and luminosity L generally expressed in absolute bolometric magnitudes M_b. Their motion along the tracks proceeds smoothly and causes no variations in principal dependencies. A marked change in the star's mass M is likely to take place at the contact stage of the evolution. After this phase of "change of parts" for stars of moderate and large masses, to our mind, complicated variations are possible for subgiants only. Constructing such dependencies is the first way of solving our problem.

The second way of clarifying the evolutionary status of different types of eclipsing binary systems is the arrangement of stars according to the stage of filling up their Roche lobes and the study of phenomena concomitant to the process. As investigations have shown, the stars, having filled up Roche lobes, lose matter which is transferred onto the neighboring star and into the surroundings. Matter transfer leads to structure transformation, to variation in angular momentum of a star and stellar system, and therefore to variation in the velocity of a binary system evolution. All this must be shown in the characteristics for stars and in their changes and manifested in variations in binary systems' classifications. And classes of systems are determined well enough, and their variation characterized a certain stage of the star's evolution.

2. Interrelations Between Main Parameters of Stars in Binary Systems

In order to study dependencies of luminosity, radius and temperature of stars upon their masses for different types of eclipsing binary systems, a compiled catalogue (Karetnikov and Andronov 1989) is used containing absolute characteristics for 303 eclipsing binaries. From these data the interrelations are calculated:

$$L_i \propto M_i^{\alpha} , \quad R_i \propto M_i^{\beta} , \quad T_i \propto M_i^{\gamma} , \quad (1)$$

where $i = 1, 2$. Here index $i = 1$ adopted for a more massive star of the pair, whereas i=2 is for a companion star. The magnitudes of L, R, M are expressed in solar units, whereas the effective temperature T in Kelvins. In contrast to a previous publication (Karetnikov 1990), in the given paper there is no separation of systems according to the principle of presence or absence of the orbital period variations.

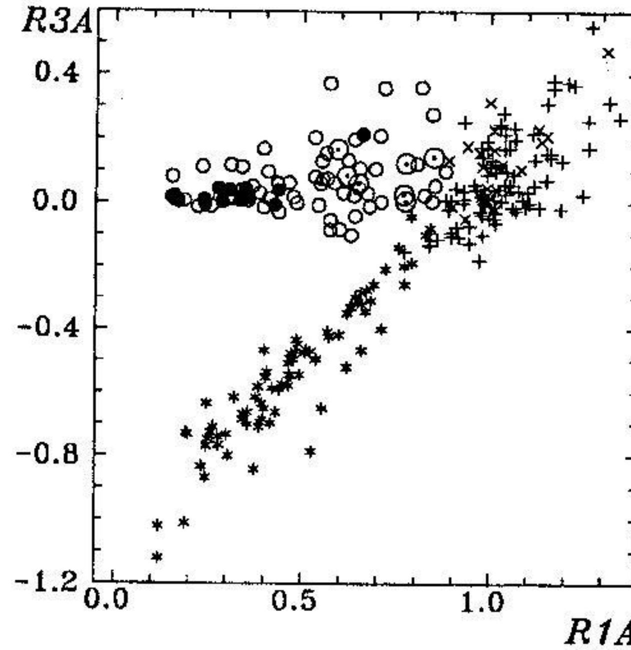

Figure 1: Diagram of filling the Roche lobes for the eclipsing binaries of the types: MS with $M < 1.5M_\odot$ (open circles); MS with $M > 1.5M_\odot$ (filled circles); $SimCW$ (⊙); CW (×); CE (+); SD (∗).

Calculated results of the relations (1) are summarized in Table 1, where designations of $MS1$– form denote a more massive star of the MS– system and the like. The stars in Table 1 are arranged on the principle of decreasing the index α by means of which the star's displacement inside the Main Sequence and beyond it can be described. As it should be expected, initial characteristics of parameters α, β and γ are noticed among the most evolved young companion-stars of the MS– systems and distinctly visualized is the transition from the main sequence stars to the subgiant-stars ($SD2$, $DS2$, $AR1$, $AR2$). The stellar arrangement suggested, in our opining, really reflects the evolutionary sequence but we cannot affirm all the stellar systems to pass consequently all these types of stars.

Now let as consider the problem of filling up

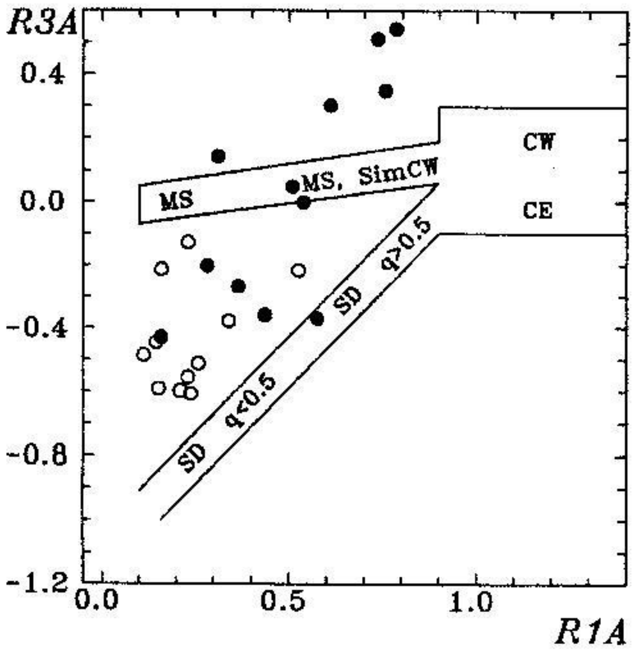

Figure 2: Diagram of filling the Roche lobes for the eclipsing binaries of the types *DS* (open circles) and *AR* (filled circles).

Roche lobes with stars of eclipsing binary systems of different types by using the catalogue (Karetnikov and Andronov 1989) data. We determine the stage of filling up as

$$\begin{aligned} R1A &= R_1/RR_1 \\ R2A &= R_2/RR_2 \\ R3A &= R1A - R2A \end{aligned} \qquad (2)$$

where $R1A$ and $R2A$ are the stages of filling up Roche lobes with more or less massive star of the system respectively, R_1 and R_2 are radii of these stars, whereas RR_1 and RR_2 are radii of Roche lobes calculated from Iben and Tutukov's (1984) formula fitting well in a wide range of the stellar masses

$$RR_i = 0.52\ A\ (M_i/M)^{0.44} \qquad (3)$$

Where A is the distance between stars in solar radii, M_i are the stellar masses, whereas $M = M_1 + M_2$ in masses of the Sun.

The comparison between magnitudes of $R1A$ and $R2A$, which can be called as reduced stellar radii, has shown that the best relative arrangement is illustrated for different types of eclipsing binaries in "$R1A - R3A$"- coordinates. The diagram constructed in the coordinates is represented in Figure 1 where circles mark positions of MS- systems (light circles - with masses $M < 1.5M_\odot$, dark ones - with $M > 1.5M_\odot$), the $\odot$ symbol denotes positions of SimCW- systems, the $\times$ symbol - positions of W UMa-type stars (CW- systems), the + symbol - positions of CE- systems and the asterics - of SD- systems. The disposition of DS- and AR- systems is shown in Figure 2. In Figure 1 are plotted dispositions of 75 MS-systems, 7 systems of $SimCW$-type, 24 CW-systems, 89 CE- systems and 83 SD- systems, all in all 278 eclipsing binary stars.

It is seen from Figure 1 that binary systems consisting of two stars of the main sequence and comprising the first group of the systems provide a sequence which is expressed by a formula (Karetnikov 1987):

$$R3A = -0.02 + 0.17{\cdot}R1A \qquad (4)$$
$$\pm.03 \ \pm.05$$

For stars of SD- systems, where a companion is a subgiant-star, one can also observe a steady sequence given by formula (Karetnikov 1987):

$$R3A = -1.11 + 1.20{\cdot}R1A \qquad (5)$$
$$\pm.02 \ \pm.05$$

The two above sequences are crossed in the region of contact systems with the values $R1A = 1.05$, $R3A = 0.16$ and represented in Figure 1 with a solid and dash lines respectively.

The proposed sequences are of evolutionary character. Indeed, the stars of MS- systems within their evolution, while proceeding through hydrogen burning in the cores, increase in their sizes, a more massive star attaining this faster. Then reduced stellar radii grow in such a way that both $R1A$ and $R3A$ increase. The growth of these magnitudes may be also due to the evolutionary decrease in the binary system sizes because of angular momentum loss, e.g. in the magnetic stellar wind in low mass stars that will result in the decrease of Roche lobe sizes and increase of relative stellar radii. Hence, the supposition on the evolution of MS- systems along a solid line in Figure 1 from the left to the right reaching the region of contact stars is quite valid.

Table 1.

*	n	α		β		γ	
$MS2$	75	3.78 ± 0.10		0.68 ± 0.03		0.60 ± 0.02	
$MS1$	75	3.78	8	0.69	3	0.57	2
$SimCW2$	7	3.66	73	0.75	10	0.70	18
$SD1$	81	3.50	8	0.71	4	0.48	2
$DS1$	14	3.42	25	0.33	14	0.48	4
$CE1$	89	2.91	11	0.72	3	0.44	2
$CE2$	89	2.67	13	0.67	3	0.42	2
$SD2$	81	2.16	18	0.44	5	0.34	3
$DS2$	14	2.13	38	0.40	21	0.27	8
$CW1$	24	1.62	39	0.53	10	0.17	8
$SimCW1$	7	1.10	11	0.45	6	0.16	5
$CW2$	24	0.98	36	0.35	10	0.04	8

Evolutionary character of the sequence for MS- systems in the diagram "$R1A - R3A$" is confirmed by the stellar separation into groups of low mass and slowly evolved stars (light circles in Fig. 1.) and more massive and faster evolved stars. The group of low mass systems is located in the left part of the sequence with a mean value $R1A = 0.3$ and mass ratio $q = 0.8 - 1.0$, whereas the group of massive systems has mean values $R1A = 0.6$ and $q = 0.1 - 0.8$. It should be noted that limited filling up Roche lobes with low mass systems amounts to $R1A = 0.65$, and with more massive systems – to 0.88. These are likely to be the limits of filling up Roche lobes, within the transition of which the stars of MS- systems change their general characteristics and become systems of other types.

Table 2.

q	$R1A$	n
0.15	0.35	15
0.23	0.44	14
0.27	0.51	16
0.35	0.52	16
0.51	0.62	14

The sequence of SD– systems shown in Figure 1 with dotted lines does not separate the stellar systems from masses. However, with stellar mass ratio q there is such a tendency. According to the statistics with $q < 0.25$ about 80 % of SD– systems have $R1A < 0.50$, and with $q > 0.25$ about 60 % of stars given $R1A > 0.50$. These averaged data are listed in Table 2 and confirm the above said (Karetnikov and Kutsenko 1988). Table 2 can be interpreted as follows: within its evolution a low mass star of SD– system loses matter which partially goes away into space and partially is accreted. This results in a steady decrease of mass ratio q, whereas the increase of accretor's mass leads to the growth of sizes of its Roche lobe and decrease in $R1A$. Thus, evolutionary decrease in q is followed by the decrease in the stage of filling up $R1A$.

3. Proposals for Evolution of Eclipsing Binary Systems

The suggested ways of the systems' evolution can be calculated for low mass MS- systems. With the stellar masses less than 1.5 $M_\odot$, as was shown by Karetnikov (1990ab) due to the magnetic stellar wind these systems lose an angular momentum and we thus have

$$(\dot{P}/P)_{MW} = -6.9 \cdot 10^{-10} \times \times \frac{(M_1+M_2)^{1/3}}{M_1 M_2} \frac{R_1^4 M_1 + R_2^4 M_2}{P^{10/3}} \ 1/\mathrm{yr} \quad (6)$$

The investigation of the formula defines time needed for the variation in the orbital period P_0 to the current P suggestive of invariability in the stellar masses and radii. This time is defined by the formula

$$\Delta t = t - t_0 = -4.3 \cdot 10^8 \times$$
$$\times \frac{M_1 M_2}{(M_1+M_2)^{1/3}} \frac{P^{10/3} - P_0^{10/3}}{R_1^4 M_1 + R_2^4 M_2} \text{ yr} \quad (7)$$

As is seen from the calculations represented in Table 3, low mass MS– systems of the group with a mean orbital period about 6.12 days can acquire properties of $SimCW$- type stars with an average orbital period equal to 0.72 days in $2 \cdot 10^{10}$ years. This is by one order more time of hydrogen burning in their cores $(3-6 \cdot 10^9)$ yrs and transition to subgiants. However, subgiant-stars are not observed in this sequence, that is the above transition appears for the low mass MS– stars to be unreal. For the group with an average orbital period near 3.15 days, time $\Delta t = 2 \cdot 10^9$ years that is comparable with the time of hydrogen burning in the core, and these must indicate stellar properties as expanded in case B. With orbital period near 1.58 days, low mass MS– systems pass into the region of $SimCW$– systems within $\Delta t = 8.7 \cdot 10^8$ years along the solid line in Figure 1 and then of CW– systems within $\Delta t = 3.5 \cdot 10^7$ years remaining main sequence stars.

These arguments can be supported with estimation of period variations due to matter transfer by the stellar wind $(\dot{P}/P)_{SW}$ and the contribution of the magnetic stellar wind $(\dot{P}/P)_{MW}$. Mass transfer by a current mechanism in MS– systems is not noticed and therefore it is not taken into account in the given calculation. Table 4 contains calculation results from groups of stars according to their average characteristics as well as total $(\dot{P}/P)$. Magnitudes of matter losses due to the stellar wind are given by a formula (Vilkoviskij and Tambovtseva 1984):

$$\dot{M}_{SW} = 10^{-9.48} \; R_i^2 \; (T_i/10^4\text{K})^4 \; M_\odot/\text{ yr} \quad (8)$$

The estimate of calculation accuracy, with the magnitudes differing by not less than an order, suggests a predominant effect of one of the factors resulting in the orbital period increase, and the consistency of time of its variation with time of hydrogen burning in the core and the stellar system acquiring the properties of stars of another type.

Comparative analysis of the data incorporated in Table 4 is suggestive of the fact that low-mass MS– systems of the stars with orbital periods about 1.58 days (MS–3) pass the stages of $SimCW$– and CW– systems and then merge into one star within time $\Delta t = 5 \cdot 10^5$ years (by using formula (6) and taking $A = R_1 - R_2$ in it). There must be no burnt out core in the single star formed. The group of MS–2 systems within the limits of error in calculations has practically no orbital period variations and is likely to pass into the group of AR–2 stellar systems. The stars of the group in MS–1 system slowly increase in their orbital periods and within hydrogen burning in the cores and transition into the subgiants' stage can pass into the group of binary systems with properties of stars of the AR–1 group.

For stars of CE– systems the separation is also done from their masses and periods. The suggested separation confirms the separation of the systems into massive, intermediate and low mass groups according to Svechnikov (1986). However, for low–mass objects a more delicate separation is needed taking account of both mass and orbital period of the binary system. The attempt made for such a separation is displayed in Table 5 containing also 3 groups of objects for low mass CE– systems. It is seen from the table that low mass CE– systems of stars show variations in their periods similar to MS– systems, and some part can be expected to pass into CW– systems (CE–a and the tail CE–b), and another part is likely to pass into other objects, but this question needs some complementary investigation.

Virtually, our arguments are preliminary and require reliable observational supports. The latter imply the systems of CW– stars comprising two groups of stars which must consist of objects close to low–mass MS– and CE– systems. The separation of CW– systems into A and W groups (Binnendijk 1965) seems to represented the division of these systems but it is not clear whether it supports our hypothesis. Another factor which could be used to strengthen the hypothesis on the transition of

Table 3.

*	n	P	M_1	M_2	A	R_1	R_2	$R1A$	$R2A$
$MS-1$	5	6.12	1.29	1.21	18.96	1.50	1.33	0.20	0.18
$MS-2$	5	3.15	1.34	1.30	12.47	1.69	1.61	0.32	0.34
$MS-3$	5	1.58	1.00	0.90	6.92	1.01	0.92	0.36	0.36
$SimCW$	7	0.72	1.07	0.84	4.14	1.18	0.94	0.72	0.63
CW	18	0.34	1.06	0.55	2.39	1.07	0.69	1.04	0.89
$AR-1$	5	6.80	1.26	1.03	19.83	3.61	3.20	0.45	0.44
$AR-2$	7	3.59	1.40	1.28	13.58	2.82	2.39	0.53	0.47

Table 4.

*	n	P	$\dot{M}_{SW}$	$(\dot{P}/P)_{SW}$	$(\dot{P}/P)_{MW}$	$(\dot{P}/P)$, yr^{-1}
$MS-1$	5	6.12	$2.3 \cdot 10^{-10}$	$+2 \cdot 10^{-10}$	$-3 \cdot 10^{-11}$	$+2 \cdot 10^{-10}$
$MS-2$	5	3.15	$2.9 \cdot 10^{-10}$	$+2 \cdot 10^{-10}$	$-3 \cdot 10^{-10}$	0
$MS-3$	5	1.58	$1.5 \cdot 10^{-10}$	$+1 \cdot 10^{-10}$	$-1 \cdot 10^{-9}$	$-1 \cdot 10^{-9}$
$SimCW$	7	0.72	$0.8 \cdot 10^{-10}$	$+1 \cdot 10^{-10}$	$-1 \cdot 10^{-8}$	$-1 \cdot 10^{-8}$
CW	18	0.34	$0.8 \cdot 10^{-10}$	$+1 \cdot 10^{-10}$	$-1 \cdot 10^{-7}$	$-1 \cdot 10^{-7}$
$AR-1$	5	6.80	$5.7 \cdot 10^{-10}$	$+4 \cdot 10^{-10}$	$-4 \cdot 10^{-10}$	0
$AR-2$	7	3.59	$9.5 \cdot 10^{-10}$	$+8 \cdot 10^{-10}$	$-9 \cdot 10^{-10}$	$-1 \cdot 10^{-10}$

low mass stars to $CW-$ systems is an observed peculiarity of $CW-$ systems as multiple stars. As Istomin (1987) has shown, 80 % of these systems are multiple. Then it is necessary to search for multiplicity in low mass MS–3 and CE–a systems. This work is being carried out by our researchers.

Analogous research work on other types of eclipsing binary stars (SD–, DS– systems) is rather unreliable due to scanty knowledge of current processes occurring there, particularly, of matter transfer and its accretion, and also due to a subgiant star present in the systems showing a complicated track in the "spectrum–luminosity" diagram. This is not favored by the stellar separation into groups of AO Cas- type (massive pairs), of β Per– type (normal pairs), eclipsing systems with "a double contact" (Pustylnik 1989), as well as systems with a small ratio of masses of R CMa–type. Until the problem of numerical determination of matter transfer in eclipsing binaries of SD- and DS- systems is solved, the calculations of their evolution can be of scenery character only. Thus, the problem of empirical determination of evolution in these systems is to be solved.

Location of sequences of the DS– and AR– systems is illustrated by Fig.2. Analysis of Fig.2. shows that the DS– systems are located similar to the SD– systems. However, the unsufficient knowledge of the absolute characteristics does not allow to discuss the observed sequence surely. Calculations of $(\dot{P}/P)$ argue for a general increase of the orbital periods of these systems. The location of the AR– systems arizing near the region of the degree of filling the Roche lobe by the massive MS– systems at $R1A = 0.5 - 0.6$ indirectly argue for a suggestion that the AR– systems evolved from the low–mass MS– systems with large orbital periods. In this case, as one may see from Tables 3,4, the safety of the mass of the stars in a pair, as well as the period increase up to observed values, and as the transition of the stars to a subgiant stage.

Our empirical studies, in general, confirm theoretical scenaria by different authors, which are sufficiently good described by Masevich and Tutukov (1988) and other articles. However, in this paper we tried to describe the works on detailization of the evolutionary directions of separate types of the eclipsing binaries and on interrelations between these types. It seems to us, that the shown results confirm:

1) the idea of the transitions from one type of the eclipsing binary stars into another;

2) the binarity of the "contact" evolutionary stage of the systems, at which a part of the stars finishes its way as the binary stars (low-mass, short-period *MS*–, *SimCW*–, *CW*–, *CE*– systems of stars), merging into one object; the rest evolving to other types of the eclipsing binary stars with the formation of subgiant stars.

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ON ESTIMATES OF LOWER AND UPPER LIMITS FOR THE MASSES OF COMPACT COMPONENTS IN CLOSE BINARIES

G. Beskin, N. Borisov, L. Pulstil'nik
Special Astrophisical Obsevatory, Russia

ABSTRACT. A method of the determination of limits for a compact component mass on the base of disk emission lines parameters is described. Lower limit of mass depends upon the distance between maxima in double peaked lines, upper upon full width of line. The method is tested for some cataclysmic variables with well-known masses of compact components. It is obtained a lower limit for the mass of the compact object in the close binary SS 433 is $4.9M_\odot$. This component apparently is a black hole.

Key words: Stars: Binaries, Accretion Disks

INHOMOGENEITIES OF CHEMICAL COMPOSITION AND COSMOCHRONOLOGY PROBLEMS

V. G. Klochkova, V. E. Panchuk
Special Astrophysical Observatory RAS
Nizhniy Arkhyz, Stavropol'skii Kraii, 357147 Russia
E-mail: vkloch@sao.stavropol.su

ABSTRACT. The problems of determination of chemical composition of stars and connection with theory of chemical evolution of Galaxy are discussed.

Key words: Stars: abundances, evolution

The sequence and the details of the events provided the origin of different chemical elements has to be in general outlines restored uniting the results of nucleosynthesis calculations, the spectroscopic study of the chemical composition of stars and the data of cosmochemistry of meteorites. But the reliability of the different methods of age determination is limited by the availability of the unhomogeneities of chemical composition. The models of chemical evolution of the galactic disc are based on the assumption about an instantaneous recycling approximation. A such approach means a full matter mixing right away past a dredge up of the productions of stellar nucleosynthesis into the interstellar medium. For all that the observed unhomogeneities of a chemical composition from star to star are explained by systematic errors. However our unvestigations of chemical composition of stars, performed at 6-m telescope in 80th years; indicated on the availability in the galactic disc of real unhomogeneities of the chemical composition as from star to star inside of stellar clusters as between different galactic clusters. The spectroscopic observations from IUE showed that the unhomogeneities of chemical composition of gaseous part of interstellar medium have the same dispersion (0.1 dex) as for the stellar population in the galactic disc. The account of these results remove a lot of problems, for example, even the simplest approach of chemically unhomogeneous interstellar matter allows to reproduce most succesfully the G - dwarfs metallicity function. The estimations of the galactic radial abundance gradients, spectroscopically obtained, do not have a statistical validity taking into account the noted dispersion value.

The phenomena, noted immediately on chemical separation of matter into gaseous-dust envelopes of the selected type stars (the λ Boo stars on the main sequence and the stars post asymptotic giants branch), are now available for spectroscopists. There are not for the present any observed confirmations for processes, opposite to the separation. It is unclear where and how the "smoothing" of the chemical composition of the selected areas of the galactic disc is going after the transition of the different atoms and ions into solid fractions. We do not also see the results of such "smoothing".

The idea on matter unhomogeneity is also very fruitful for the interpretation of some details of the chemical composition in the Solar system. The following conclusions have to be made from the observed radiogeneous isotopic variations: a) there are more than two types of primordial matter with different nucleogeneous history into the Solar system; b) the Solar system was initially isotopic heterogeneous and retain this property. A mechanism of origin of the chemical and isotopic anomalies in the protosolar nebula is based on the separation of the near Supernovae matter on gas and dust with the following dust injection in the outer layers of a nebula. In general the results of the investigation of the chemical composition of the Solar system insist on refuse from the persistent nucleosynthesis model. As summary the persistent – discrete model, where an exponential slope of the stellar nucleosynthesis is added by the next discrete peaks, is suggested. Thus the discover of chemical unhomogeneities of protostellar, stellar and protosolar matter complicates the problem of a determination of an object age using its chemical composition and leads to the necessary of a development and an inclusion into chemical evolution models of approximations accounted an influence of phases "gas-dust" transitions.

The classic method of an age determination using the isochrones, calculated with given helium and heavy elements abundances, has also the problems. For example, an age of individual stars in the galactic field is determined without problems, but the use of a such method for the stars inside open clusters leads to the age dispersion that exceeds, as a rule, a cluster age, derived by turning-point. Our investigations show that the age determination "errors" do not correlate with individual differences of chemical composition.

The investigations of far field galaxies show that the probability of merging of two galaxies is sufficiently high. The evidents of a such merging of the our Galaxy with the Magellanic Clouds system are found. This complicates some more the creation of a self-consistent picture of the chemical evolution of the Galaxy.

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INTERPRETATION AND SOLUTION OF THE LIGHT CURVE OF THE WOLF-RAYET ECLIPSING BINARY CQ CEP

T. A. Kartasheva[1], M. A. Svechnikov[2]
[1] Special Astrophysical Observatory of RAS
[2] Chelyabinsk State University

ABSTRACT. In spite of authors of numerous solutions of light curve of CQ Cep, which consider the latter as caused basically by effects of ellipsoidal form and components eclipse, we continue to insist upon the compound character of light curve of this very close system.

We consider that about a half of amplitude of overwhelming majority of light curves of CQ Cep is caused by light variability of common system envelope which is utmost inhomogeneous is density and only a half is connected with the effects of ellipsoidal form and component eclipse.

As a result of light curve correction for orbital eccentricity and introduction into consideration of a third brightness (the brightness of common envelope) a more precise solution has been obtained for light curve with the most low amplitude and, probably, less distorted by envelope inhomogeneities.

The analysis of this solution allowed us to make more precise determination of the companion luminosity class, and to understand the reason of difficult detection of lines of the latter in the system spectrum, to make more precise the model of CQ Cep and its evolution in time, to understand the nature of high amplitude light curve of the system.

Key words: Stars: Eclipsing Binaries, WR

CHEMICAL COMPOSITION OF ATMOSPHERES OF COOL GIANT STARS

N. S. Komarov
Astronomical Observatory, Odessa State University,
T.G.Shevchenko Park, Odessa 270014 Ukraine
E-mail: root@astro.odessa.ua

ABSTRACT. Results of determination of abundances of chemical elements in the atmospheres of 57 giant stars of the oxygen sequence of the Galactic disk are given. A brief survey of findings is presented making it possible to draw conclusion on evolution of abundances of chemical elements in the atmospheres of cool stars at the transition stages from the main sequence (MS) to that of the red giant (FRGB), from the upper boundary of a giant branch to the horizontal one, and eventually, at the stage of asymptotic giant branch (AGB). The rate of stellar evolution, efficiency of mixing depends on initial mass of the stars and primordial chemical composition of the progenitor matter.

Key words: Stars: abundances, giant, evolution, nucleosynthesis.

One of the problems of modern astrophysics is the testing of theories of nucleosynthesis and stellar evolution, chemical and dynamical evolution of the Galaxy based upon data of abundances of chemical elements in various objects of the Galaxy. Particularly, it is necessary to know most precisely about the abundance of chemical elements and their isotopes in the atmospheres of stars of different masses which have proceeded through one or another stage of evolution. For such investigation the most convenient object are cool stars – giants and supergiants. This is the fact that these are the brightest objects of stellar population in the Galaxy and their spectra contain a great number of absorption and/or emission lines of various chemical elements and their compounds are detected (even for stars with extreme iron deficiency).

According to the present concepts of the stellar evolution theory, the duration of stay of the star at a certain stage (at a certain locus at the HR diagram) is essentially dependent of its mass, initial chemical composition and nucleosynthesis processes. The belonging of stars to various population types of the Galaxy, to different types of clusters and dynamic groups gives an excellent possibility of tracing the evolution of chemical composition of their atmospheres depending on their age and composition of progenitor matter. The evolution of stars with different masses and various chemical composition occurs according to various scenarios.

In this paper we shall consider results of investigation of chemical composition in the atmospheres of cool giant stars of the oxygen sequence of the Galaxy disk, which have been obtained at the Astronomical Observatory of the Odessa State University.

On the initiative of Director of the Observatory V.P.Tsessevich, in 1966 I and my colleague V.A.Pozigun manufactured an IR–spectrometer on the basis of photomultiplier RCA 7102. The photomultiplier was purchased by V.P.Tsessevich during his scientific trip to Harvard Observatory. Owing to this, my research interest came to studying cool giant stars, which have maximum radiation in this region.

Giant stars in the Galaxy disk are at various stages of evolution – the first and subsequent giant branches (FRGB and other), blue and red parts of the horizontal branch (BHB and RHB), the asymptotic giant branch (AGB), the post–asymptotic giant branch (post–AGB) and in the region HR diagram penetrating into each other. If the theory of stellar evolution pertaining to the mix of their atmospheres with products of nucleosynthesis is true, their abundances with their known fundamental characteristics stars can provide information about evolutionary status of stars, that is of its mass and chemical composition of progenitor matter (Sweigart et al. 1989).

The simplest interpretation of classification of stellar spectra made it necessary to suggest a difference between chemical compositions in the atmospheres of cool giant stars. There are stars with excess or deficiency of elements of iron group, with various ratio of abundances of carbon and oxygen, elements with even and odd Z, with excess or deficiency of the s–process elements etc.

A great number of works have been published recently on the determination of abundances in the atmospheres of stars, and therefore, other fundamental characteristics by using the spectra with a high signal–noise ratio (S/N < 300) and the method of model atmospheres. We shall consider in brief the survey of results given in literature. The readers are referred to survey (Gehren 1988) wherein this problem is presented in detail.

Stars of the main sequence (MS) of the Galaxy disk in the solar neighborhood have the following elemental abundances of CNO – group relative to the Sun : [C/H] = –0.23, [N/H] = 0.38 , [O/H] = –0.03, where $[A_i/H] = \log(A_i/H)^* - \log(A/H)^{\odot}$, where log A_i is the abundance in the scale of log $A_H = 12.0$. The ratio of abundances of isotopes ^{12}C and ^{13}C ranges from 10 to 50 (the average value $^{12}C/^{13}C = 22.5$) whereas that of $^{12}C/^{13}C$ for the solar atmosphere approximates 90.

Progenitors of G – M giant stars are the F – G dwarf stars with masses ranging from $0.8 < M/M_{\odot} < 3.0$. Therefore, in their atmospheres the products of nucleosynthesis can be expected. Virtually, for 4 and 2 giant stars of the Hyades and Praesepe clusters the current ratio C/N = 0.9 whereas for the sun (C/N) = 4.8, but for dwarf–stars of Hyades it was found to be $C/N = (C/N)_{\odot}$.

In the work by Kjaergaard et al. (1982) it was obtained that C/N = 2.3, i.e. the nitrogen abundance was found to enhance while that of carbon to decrease, incidentally, for metal deficient stars and for those with masses $< 1M_{\odot}$ the ratio $(C/N)^* = (C/N)^{\odot}$, whereas $(N/Fe)^* > (N/Fe)^{\odot}$ and $(C/Fe)^* < (C/Fe)^{\odot}$ for all the giants. At the same time the total abundance of C, N, O elements for dwarf stars and giant stars of Hyades cluster is nearly identical. It is characteristic of the atmospheres of giant stars to be carbon poor, nitrogen rich at the constant oxygen abundance as compared to the abundance of these elements in the atmospheres of dwarf stars. The abundance of chemical elements obtained for the atmospheres of field giant stars is in good agreement with that of dwarf stars in the metallicity range region $-2.4 < [Fe/H] < 0.35$, while elements of the $\alpha-$ process are overabundant in the atmospheres of metal deficient stars and while Na and Al are underabundant relative to elements $\alpha-$ process (Gratton et al. 1987). It should be noted that formal excess of some elements relative to the solar abundance can result from either hyperfine structure of atomic lines or isotopic shift.

Therefore, in determining elemental abundance it is necessary to carefully analyze the structure of a lower level of every absorption line, otherwise we can several times overestimate the elemental abundance. In the case of isotopic shift it is necessary to take into account the abundance of table isotopes of a certain chemical element. For the elements of iron group the isotopic shift is unlikely to occur since isotopes ^{52}Cr, ^{55}Mn, ^{56}Fe, ^{59}Co, ^{58}Ni are primarily observed. For elements with odd Z the hyperfine structure of atomic levels is probable. Abundance ratios of isotopes of elements C, O, Ng, Al, Si, Ca, Ti, Zr can differ from those of the Earth and give information on thermonuclear process resulting from the addition of $\alpha-$ particles and neutrons.

For sustaining the structure of a red giant the absence of full mixing between outer and inner layers is of importance. However, as was shown above, the $^{12}C/^{13}C$ isotopic ratio for giant–stars is considerably less than that of the Earth (the Sun). Of particular interest are metal–

poor red giants with [Fe/H] < –2 which are likely to be stars with low mass ($M < 0.8M_\odot$), to have originated from a cloud with mass 10^5 – 10^6 $M_\odot$. Massive stars of short lifetimes supply the cloud with different metals and products of the CNO–cycle. Variations in intensity bands of CN, CH and NH indicate that red giants originated from progenitor matter with various ratio of nucleosynthesis products. In this respect, rather illustrative is the Cas A object – a remnant of the supernova flared up approximately 300 year ago. The clouds is found with a primary oxygen abundance ([H/O] = –3.7, [He/O] < –1.9 and [C/O] < –2.1). Lines of S, Ar and Ca elements are visible. This means that the star is at the evolutionary presupernova stage, has layer structure, and thicknesses of corresponding layers depend on initial mass of the star.

The determination of elemental abundances in the atmospheres of cool stars is to a greater extent associated with the problem of determining fundamental characteristics, i.e. effective temperatures T_{eff}, on gravities on the surface (g), metallicities ([Fe/H]), microturbulent velocities [V], with that of calculation of model atmospheres adequate to the structure of atmospheres of real stars, with that of determining the physical – chemical radiation and collision parameters of atoms and molecules (Ridgway et al. 1980, Komarov et al. 1985, Korotina et al. 1992).

The value of microturbulent velocity V_t in the first approximation was estimated from the curve of growth for absorption lines Fe I. The value V_t was revised by the method of model atmospheres by means of calculation of abundance log A_{Fe}. The correlation between log A_{Fe} and W_λ was found, and the value V_t was selected when there was no correlation between log A_{Fe} and W_λ. The influence of rotation and macroturbulence on the profile of absorption lines was taken into account by the convolution of a synthetic spectrum with the apparatus function of a spectral device. It is suggested that broadening of a profile of the line due to rotation and macroturbulence are small as compared to those caused by the apparatus function of the device.

For cool stars it is difficult to select relatively pure absorption lines by taking no account of a synthetic spectrum and its convolution with the apparatus function of the device as the apparatus function of a spectral device. The apparatus function of a spectral device was taken the Gaussian with a half-width equal to spectral resolution. For selecting pure and weakly blended absorption lines the calculation of synthetic spectra were carried out. The model atmospheres was taken from the grid (Bell et al. 1978) with parameters T_{eff}, log g, [Fe/H] corresponding to K0 III and K5 III stars, but namely (5000, 3.00, 0.0) and (4000, 1.50, 0.0), respectively.

The same stars γ Tau, δ Tau, ϵ Tau clusters of Hyades, α Tau, γ Sge their parameters and chemical composition were found from spectrograms with reciprocal dispersion not worse than 5.6 Å/mm with the wavelength range 5360 – 6700 Å. In the same detail chemical composition of stars BS 3427 and BS 3428 of open cluster Praesepe was investigated (Komarov et al. 1985ab, 1992, Mishenina et al. 1986, Gopka et al. 1990ab).

In analyzing results of chemical abundances in the atmospheres of cool giant stars of oxygen sequence it is necessary to take into account the belonging of stars to various stages of star formation (Korotina et al. 1989, 1992) and their evolutions on different ascending branches of giant stars, horizontal branches of giant it this or that transition, and asymptotic branches of giants. It is related to our possibility of only rough estimating field stars' mass and in even such assumption there arises a question on reliability of the results. We check the evolutionary status of a star from it position in the HR diagram but at the same locus of HR diagram can be located stars proceeding different stages of evolution affected by distinctions in masses and initial chemical composition of protostar matter. The best position of stars seemed to be those belonging to the open clusters or dynamical groups because of a possibility of estimating there age. But here we come across a paradox. As is known from (Korotina et al. 1989, 1992), the relative quantity of stars of G5 III – K0 III spectral types with a "standard" chemical composition must be small but that of stars in K2 III – K5 III range with "standard" chemical composition is predominant. However, in the most nearby open Hyades and Praesepe clusters the K0 III giant stars have "standard" abundance (except for same elements C, O, Na) whereas in the most well studied dynamical group the α Boo star (K2 IIIp) is certain to be metal–deficient. In the analysis and comparisons of results obtained by the various authors the abundances should be given relative to hydrogen in the same star rather than relative to abundance in the solar atmospheres. From our data the abundances in atmospheres of 57 giant stars belonging to the disk of Galaxy are obtained.

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PHOTOMETRIC STUDY OF A NEW X–RAY SOURCE – THE ECLIPSING POLAR RXJ 2107.9–0518

E. P. Pavlenko
Crimean Astrophysical Observatory, Nauchny 334413 Crimea, Ukraine
E-mail: pavlenko@crao.crimea.ua

ABSTRACT. The object RXJ 2107.9–0518 was discovered as a soft X–ray source at the space observatory ROSAT in 1990. Its X–ray spectrum is characteristic to the systems of the AM Her type thus the object was suspected to be a polar. The first photometric study of this object were obtained in 1992 independently at two observatories: in August–October by Schwope et al. at the 90–cm ESO telescope and in November–December by us at the 50-cm telescope of the Crimean Astrophysical Observatory.

Our photometry confirmed the preliminary classification of this source as a polar with an orbital period of 125 minutes. The eclipses were detected with a duration of nearly 10 minutes and with depth $\geq 3.5^m$. It was found that the eclipsed emission source is shifted in respect to the line of centers at 32°. The morphology of the light curves is consistent with two active magnetic poles the power of which changes with time similar to BY Cam.

Key words: Stars: Cataclysmic Variables; Polars.

ANISOTROPIC STELLAR WIND IN CLOSE BINARIES WITH NON-RELATIVISTIC COMPONENTS: OBSERVATIONAL EVIDENCES AND THEORETICAL IMPLICATIONS

I. Pustylnik
Institute of Astrophysics and Atmospheric Physics,
Tartu Astrophysical Observatory, Tõravere, EE2444, Estonia
E-mail: izold@mars.aai.ee

ABSTRACT. Some of the most important issues of anisotropic stellar wind research in close binaries with non-relativistic components, basically Algol-type stars, serpentides and early-type contact systems are briefly discussed with an emphasis on the problems of origin of anisotropy, morphology of gas, observable effects of wind upon spectra and light curves, the angular momentum loss and the evolutionary consequences.

Key words: Stars: Close Binaries; Anisotropic Stellar Wind.

1. Introduction

During the last 10-15 years the problem of anisotropic stellar wind in close binaries has received a considerable attention both from the observers and theoreticians. The underlying reasons for that are multifold but actually are self-explanatory. Firstly, there is a plentiful evidence suggesting that early-type MS stars and supergiants of all spectral classes lose mass at a rate $\dot{M} = 10^{-6} - 10^{-4} M_{\odot}$ per year. For typical velocities of expansion $v_{esc} = 10^2 - 10^3$ km·s^{-1} and characteristic size of the orbit $a \sim 10^{12} - 10^{13}$cm this would mean optical depths of circumbinary gas of order $\tau \sim 0.1 - 1.0$, quite sufficient to influence both continuum and the line spectra of a binary system. In case of an optically thick stellar wind the accretion luminosities may be comparable to the intrinsic luminosities of the accreting star and thus may significantly alter the picture based upon assumptions of conventional theories. Secondly, morphology and dynamics of an ambient gas is governed by the interaction of gas (often in transonic flow) with the components and the consequences of it are often observed. Besides, the importance of studying various aspects of stellar wind problem is underscored by the fact that stable accretion discs cannot be formed in many cases whereas stellar wind is present practically in all binaries. Last but not least, it has been indicated that for the components of spectral type later than F5 with the convective envelopes magnetic stellar wind appears to be a very effective mechanism of redistributing the angular momentum and thus drastically changing the orbital elements which in its turn will have profound consequences for the future evolutionary status of a binary (this is especially valid for contact systems, both early-type and W UMa type stars).

In sum stellar wind permeats practically all important aspects of astrophysical research of close binary systems. But its full role in shaping the overall picture of the observed phenomena in these systems and the underlying processes are far from being fully understood. Here we give just a sketchy review of some of the key issues of anisotropic stellar wind problems:

a) anisotropy, colliding winds, morphology and clumpy structure,

b) the effect of wind upon the spectra and the light curves,
c) angular momentum loss and evolutionary consequences.

2. Anisotropy, Interacting Winds, Morphology

Anisotropy of stellar wind stems from the very binary nature of the system even if the wind is associated just with one of the components and is virtually absent for a companion star. Anisotropy is caused by the displacement of a sonic point induced by the periodically varying gravitational attraction of a companion star (Friend and Castor 1982, Hadrava 1985) or may be induced radiatively (Basko and Sunyaev 1973; Modisette and Kondo 1980). Recently we have derived a fairly simple expression for an estimate of the relative displacement of a sonic point (Pustylnik 1994) valid for a radially expanding wind in an adiabatic case

$$\frac{\Delta r_s}{r_s} \simeq \frac{1}{4} f(r_s)\, q\, r_s^2 \frac{u_e^2}{u_s^2}\,, \qquad (1)$$

where $\Delta r_s/r_s$ is the relative displacement of a sonic point (in comparison with a single star), q is the mass ratio, u_e is the escape velocity from a binary system and u_s is sonic velocity whereas $f(r_s, q) \sim 1$ is an elementary function, r_s is expressed in units of the semi-major axis. Thus, it follows from (1) that the relative displacement is of order of $10^{-3} - 10^{-2}$ of a stellar radius which is comparable to the scale of the chromosphere. Since the mass loss rate $\dot{M} = 4\pi \rho_s u_s r_s^2$ depends primarily on the density of gas ρ which is very sensitive to the depth in the chromosphere (u_s scales as the square root of a temperature but the accompanying changes with the depth would be much smaller) the net result should be higher mass flux in the directions pointing to the companion star.

Geometry of wind is either incorporated with the aid of ad hoc stream tubes (Modisette and Kondo 1980, Haisch et al. 1980 , Kopp and Holzer 1976) or for a simple model of evaporative stellar wind by fixing the ratio of gravitational potential of a binary to the total energy of a gas particle (Pustylnik 1994). Even in this latter relatively simple case geometry of wind is strongly dependant on the temperature T_{gas}. For hot gas $T_{gas} \geq 10^6\,K$ the wind may be nearly isotropical, whereas for $T_{gas} \simeq 10^4\,K$ transonic flow is realized,i.e. the shocks and the clumpy structure will be the inevitable consequences . In the intermediate case $T_{gas} \simeq 10^5 K$ conical shape should be a good approximation, the angle subtended by the cone being determined roughly by the cros-section of the critical Roche lobe of an accreting star. In the case of accretion from stellar wind (Kolychalov and Sunyaev 1979) one should expect to find some consequences of interaction between the gas flow and the disk and indeed in some interacting binary systems these effects have been observed (for instance in UW CMa, Eaton 1979).

Modelling of colliding wind structure and dynamics has become one of the most topical problems in stellar astrophysics during the last 10-15 years. Originally it has been worked out and applied to symbiotic stars ,novae and binaries with Wolf-Rayet type components (this topic is beyond the scope of the present report and will not be elaborated here). But more recently modelling of colliding winds proved to be a promising approach to investigation of classical interacting systems as well - serpentides, early-type contact binaries (Gies and Wiggs 1991, 1992; Luo, McCray and Low 1991; Stevens, Blondin and Pollack 1992; Kallrath 1991 and references therein). Despite of the high degree of sophistication and complicated mathematical technique the input physics is still fairly simple one (isothermal or adiabatic gas, two-dimensional models), the treatment of interaction of the winds is confined to the consequences at the impact front of the winds where dynamical pressures of the winds are equal, whereas effects of anisotropy pertinent to the binary nature and mentioned above are neglected. The most immediate effects of colliding winds from the observational aspect are formation of bow shocks around the mass accreting star, generation of significant X-ray emission (Cherepashchuk 1976) and the dependence of P Cyg type line profiles on the orientation in respect to a bow shock, line profile changes with the phase of the orbital period.

3. The Effect of Wind upon the Light Curves and Spectra of Close Binaries

There are multiple manifestations of the influence of stellar wind upon the light curves and spectra of the Algol-type stars,serpentides and early-type contact binaries. Thus, Plavec (1989) who has made a comparative analysis of UV emission lines of C IV, N V, C III, Si IV, Al III etc for 10 Algols and 6 serpentides finds no significant differences between them and concludes that these lines are formed in the wind basically due to scattering processes. The effects of wind are invariably found for the well studied interacting systems if sufficient temporal, spatial and spectral resolution is achieved. Thus Eaton (1978) from analysis of OAO-2 UV light curves of a bright early-type contact binary UW CMa finds the evidence for an expanding region of low continuum optical depth or in other words, anisotropic stellar wind from Of component producing small dips in the UV light curves during the secondary minimum. Short time variations in the intensity of stellar wind have been found from high resolution spectrum of another early type contact system SV Cen (Drechsel et al. 1982), where mass loss is of order $10^{-4}\,\dot{M}_{\odot}$/year according to the same authors. Analysis of UV resonance lines and $H\alpha$ as well as He I λ 6678 in AO Cas (Gies and Wiggs 1991) suggests that stellar wind is concentrated towards the mass accreting component, emission in $H\alpha$ originates predominantly on the hemisphere of accreting star facing the mass losing component. Similarly P Cyg type profile variations with the phase of orbital period have been detected in HD 47129 (Sahade and Brandi 1991), V 444 Cyg (Short and Brown 1988), γ Vel (Brandi, Ferrer and Sahade 1991). According to Karetnikov and Glazunova (1985), Karetnikov and Menchenkova (1987) who studied spectroscopically early-type binary systems V 367 Cyg, V 448 Cyg (by all evidence, an intermediate type of objects between serpentides and early-type contact binaries) practically all absorption lines observed in the visible range of their spectra are formed in a common envelope. A new technique has been proposed to assess the rate of mass loss (or at least to set an upper limit) directly from the light curves based on an assumption of optically thin wind from one component (Pustylnik 1994). It has been applied to an early-type system SZ Cam (Pustylnik and Polushina 1994) and an estimate $\dot{M} \simeq 5 \cdot 10^{-7} M_{\odot}$/year has been found as an average for about 50 years. Optically thick stellar wind may be unstrumental in explaining many puzzling features of the early-type contact binaries (small changes of the amplitudes of radial velocities, phase dependant estimates of spectral and luminosity types, as well as luminosity and radii excesses for the secondaries etc).

4. Angular Momentum Loss and Evolutionary Consequences

During the last decade it became clear that angular momentum loss through the stellar magnetic wind plays a crucial role in the evolutionary history of different type close binaries and can successfully explain transition of a binary from detached to a semi-detached state and from the latter to the contact stage (see, for instance, Yungelson, Tutukov and Fedorova 1989; Vilhu 1982; Iben and Tutukov 1984). With the aid of magnetic field embedded in the flow it is easy to understand at least in qualitative terms subkeplerian velocities, supersonic turbulence and high temperature regions in circumstellar material (Bolton 1989). Quite recently Tout and Hall (1991) have presented arguments in favour of the idea that at least in some cases (for the conservative case B mass transfer when mass losing component is in a giant stage with a deep convective zone) the time scale for the angular momentum loss may be shorter than the nuclear time scale for a component nearly filling in its respective critical Roche lobe. Thus they suggest that namely angular momentum loss may be the driving mechanism behind mass transfer proccess.

In this way comparable estimates for the mass transfer and mass loss rates find an interpretation. This picture also reasonably agrees with the radiodata for some Algol-type and RS CVn type systems (Owen and Gibson 1978) as well as with the alternating decreases and increases of the orbital period found in many systems (Hall and Kreiner 1980).

One of still unresolved problems of the theoretical treatment of stellar wind during the critical stages of stellar evolution is of fundamental nature. Namely, the mass transfer process has been invariably treated as the filling in of the critical Roche lobe,whereas both mass loss and mass transfer occur even when a star is far from reaching its critical Roche surface. Besides, a simple picture of the Roche equilibrium model may loose its validity during the short-lived dynamical stages of evolution.

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COMPARATIVE ANALYSIS OF PHYSICAL PARAMETERS OF RR LYRAE

Yu. S. Romanov, N. S. Zgonyaiko, S. V. Vasilyeva
Astronomical Observatory, Odessa State University,
T.G.Shevchenko Park, Odessa 270014 Ukraine
E-mail: root@astro.odessa.ua

ABSTRACT. For analysis of spectral observations of RR Lyrae obtained by Butler in 1974 with a dispersion of 8 Å/mm, a two-component "curve–of–growth" method is used which has been developed at the Odessa Astronomical Observatory. As a result, a number of physical parameters are obtained as well as their phase variations: temperature, spectral type, electron pressure, turbulent velocity. Parameters of T_{ex} and $\lg P_e$ have proved to be somewhat higher than the values found by Butler and correspond to the B9.1 – F0.9 range typical of this stellar spectral type.

Key Words: Stars: Variables: Atmospheres of–stars; Star: Individual: RR Lyrae

Table 1. Physical parameters of RR Lyrae

ψ	ϕ	T_{effBut}	T_{eff1}	T_{eff2}
0.109	0.004	6336	8087	10597
0.237	0.029	6271	7682	11175
0.062	0.148	5909	7682	
0.203	0.194			10783
0.295	0.267	6538	7879	
0.785	0.301	5691	7982	
0.295	0.338	6271	7879	
0.262	0.466	5691	7495	9173
0.272	0.540	5587	7495	8907
0.189	0.714	5638	6906	
0.236	0.799	5691	7405	
0.246	0.856	5691	7317	
0.246	0.962	6336	8656	

Spectrophotometric investigation of RR Lyrae at maximum Blazhko effect was carried out by a two–component "curve–of– growth" method by Romanov et al. (1991, 1993). As a result, a complicated variation in metal spectral types $Sp(M)_1$ and $Sp(M)_2$ has been found from ϕ phase in the B9.1– F0.9 range. Both curves show depression in the region ϕ= 0.90–0.94, minimum depression emerging somewhat earlier in upper curve $Sp(M)_2$ than in lower curve $Sp(M)_1$.

Scanty observations covering only an ascending curve of the light curve for fundamental pulsation in RR Lyrae do not permit to trace further variations in $Sp(M)_{1,\,2}$ and other parameters of the atmosphere with ϕ– phase.

Due to the method of a two–component "curve–of–growth" (Fenina & Zgonyaiko 1992), spectrophotometric observations of RR Lyrae made by Butler (1974) and embracing the whole cycle of the star's fundamental oscillation near maximum Blazhko effect have been investigated. An the work by Butler (1975), from these observations some physical and chemical characteristics of RR Lyrae relative to the Sun are determined by using differential "curve–of–growth" analysis. An particular, some effective temperatures of a spectrum–forming layer of the star are found by comparing profiles of hydrogen lines H_γ with theoretical ones. Variations in effective temperatures obtained by him lie within F3.7–G2.0 spectral range which does not correspond to the spectral range of RR Lyrae given in GCVS (1985) and in the work by Romanov et al. (1991).

Ambiguous results of spectral classification enabled to compare physical parameters θ_{ex}, θ_{eff}, $\lg P_e$, V_t determined by Butler (1975) and found by us on the basis of a two–component "curve–of–growth" method.

In Tables 1,2 we summarized results of the

Table 2. Physical parameters of RR Lyrae (continued)

ψ	ϕ	θ_{exBut}	θ_{ex1}	θ_{ex2}	$\lg P_{eBut}$	$\lg P_{e1}$	$\lg P_{e2}$	V_{t1}	V_{t2}	$[V]_{FeI}+1.3$
0.109	0.004	0.97	0.76	0.58	0.03	1.62	3.39	2.95	2.95	1.71
0.237	0.029	0.98	0.80	0.55	-0.03	1.05	3.62	2.17	2.51	1.64
0.062	0.148	1.04	0.80			1.91		3.30		
0.203	0.194			0.57	-0.52		3.72		3.30	1.61
0.295	0.267	0.94	0.78		0.36	1.74		2.47		1.75
0.785	0.301	1.08	0.77		-0.95	1.44		2.47		1.58
0.295	0.338	0.98	0.78		-0.09	2.00		3.40		1.63
0.262	0.466	1.08	0.82	0.67	-0.48	1.31		4.15		1.63
0.272	0.540	1.10	0.82	0.69	-0.59	1.24	2.68	3.25	3.40	1.60
0.189	0.714	1.09	0.89		-0.68	0.55		4.07		1.70
0.236	0.799	1.08	0.83	0.67	-0.59	1.01	2.74	2.95	2.95	1.61
0.246	0.856	1.08	0.84		-0.49	1.24		4.07		1.61
0.246	0.962	0.97	0.71		0.08	2.05		2.95		1.63

given comparison. For six spectra, "curves–of–growth" are approximated by one parameter of excitation temperature θ_{ex}, the remaining contain two components each, with two dominating parameters of excitation temperature θ_{ex1} and θ_{ex2} respectively (columns 7 and 8).

In Tables 1,2 we also presented phases of the fundamental oscillation ϕ and those of Blazhko effect ψ of RR Lyrae calculated from data by Romanov et al. (1981); effective temperatures calculated on the basis of parameters θ_{ex} by using the formula

$$T_{eff1,2} = 0.8\frac{(5040)}{\theta_{ex1,2}} \qquad (1)$$

parameters of excitation temperature $\theta_{ex1,2}$ obtained from the two–component "curves–of–growth"; electron pressure according to Boltzmann–Saha equation $\lg P_{e1,2}$; turbulent velocities $V_{t1,2}$. Parameters with the index "But" are taken from the work (Butler 1974).

Comparison has shown that more effective temperatures correspond to the spectral range of GCVS. Electron pressure $\lg P_{e1,2}$ is lineally dependent on θ_{ex} and consistent with ionization equilibrium position in similar stationary stars. Turbulent velocities of the order of 3–4 km/sec correspond to the typical ones for the given stellar type.

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MODELS OF CIRCUMSTELLAR MASERS IN BIPOLAR OUTFLOWS

G. M. Rudnitskij
Sternberg Astronomical Institute, Moscow State University
13 Universitetskij prospekt, Moscow 119899, Russia
E-mail: gmr@sai.msk.su

ABSTRACT. Sources of molecular maser radio emission in envelopes of late-type variable stars (red giants and supergiants) are considered. Radio and optical data on asymmetry of mass loss process in red giants are briefly reviewed. Main attention is paid to maser emission in the H_2O rotational transition $6_{16} - 5_{23}$ ($\lambda = 1.35$ cm) of M-type supergiants (VX Sgr, VY CMa). Results of single-dish and interferometric studies of H_2O maser emission of these stars are discussed. It is shown that circumstellar H_2O masers in VX Sgr fit in a model of a rotating circumstellar gas-dust disc and a bipolar outflow of matter directed along the disc axis.

Key Words: Stars: Late-Type, Stars: Mass Loss, Stars: Circumstellar Envelopes, Maser Sources, Bipolar Outflows, Stars: Individual: VX Sgr, VY CMa.

At present, several hundreds of late-type stars of spectral types M, C, and S (most of them are Mira-type or semiregular variables) are known to emit maser or thermal radio emission in spectral lines of molecules (Cesaroni et al. 1988; Engels and Heske, 1989; Benson et al. 1990; Loup et al. 1992). Oxygen-rich (M-type) stars emit maser lines of the oxygen-bearing molecules OH, H_2O, and SiO. Carbon stars emit thermal lines of CO and HCN; a few carbon stars are also HCN masers. CO radio emission appears in many oxygen-rich stars as well. A small number of S-type stars emit maser lines of SiO.

Maser emission of late-type stars is observed at the evolutionary stage of intense mass loss when the stars are on the asymptotic giant branch (AGB). At this stage, the stars are surrounded by extended gas-dust envelopes formed by outflowing material. Physical conditions in the circumstellar envelopes are favourable for nonequilibrium excitation of molecules, resulting in maser effect.

The AGB stage is critical in evolution of stars, because stars lose a considerable part of their masses. This results, on one hand, in a quick transition of a star from the red-giant stage to that of "white dwarf + planetary nebula", and, on the other, in enrichment of interstellar medium with stellar ejecta (dust and gas with heavy elements).

Masers in different molecular lines originate in different layers of the circumstellar envelopes. OH molecules emit from the outer parts of the envelopes ($r \sim 10^{16}$ cm), H_2O – at closer distances to stellar surfaces ($r \sim 10^{14} - 10^{15}$ cm). SiO and HCN maser emission comes from vibrationally excited states of these molecules and requires much more energy for excitation. Therefore, SiO masers in M- and S-type stars, and HCN masers in carbon stars are located in the innermost parts of the circumstellar envelopes, at $r \sim$ a few $\times 10^{13}$ cm, near stellar photospheres.

In this contribution, I consider circumstellar maser emission in the rotational transition $6_{16} - 5_{23}$ of the H_2O molecule ($\lambda = 1.35$ cm). The maser pair of H_2O rotational levels is located high enough above the ground level, $T_{exc} = 644$ K. The H_2O maser is thus of intermediate degree of excitation among other circumstellar masers. The H_2O maser is of interest for studies of mass loss process, because it probes those layers of circumstellar envelopes,

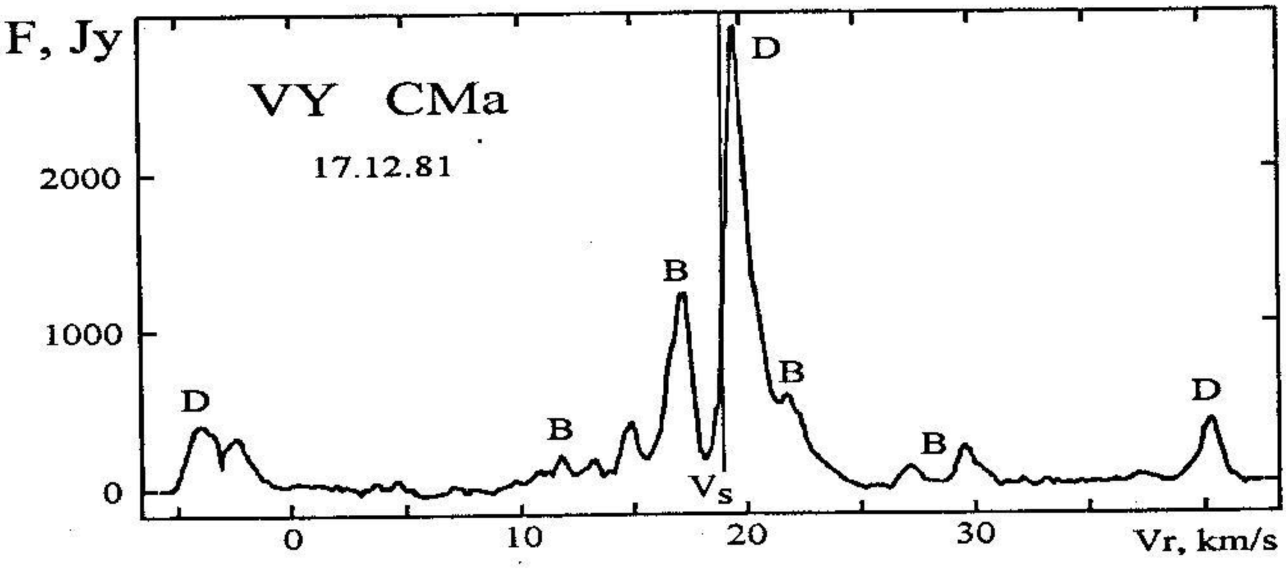

Figure 1: Profile of the H_2O line $\lambda = 1.35$ cm of the supergiant VY CMa, observed on the Pushchino 22-meter radio telescope of the Lebedev Physical Institute, Russian Academy of Sciences (flux density in Janskys *vs* radial velocity with respect to the local standard of rest in km/s). Radial velocity of the star $V_s = 19$ km/s (Loup et al. 1992).

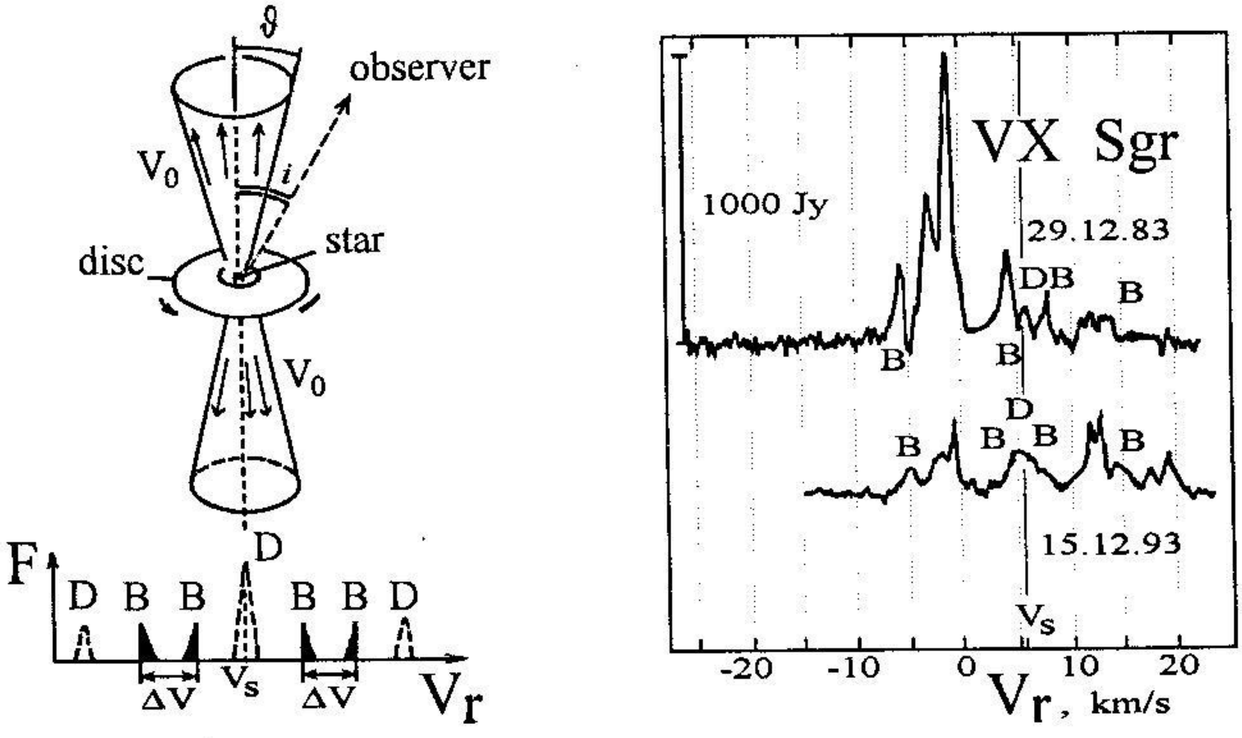

Figure 2: *Left:* Bipolar geometry is shown together with the expected line profile (see text). Separation between spectral features within each pair $\Delta V = 2V_0 \sin\vartheta \sin i$. *Right:* Same as Fig. 1, for VX Sgr, observed in 1983 and 1993; $V_s = 5.3$ km/s (Chapman and Cohen 1986).

in which main acceleration of the outflowing material takes place.

There are much data indicating that mass loss from AGB stars is not a smooth, spherically symmetric flow of gas and dust. These data include optical and infrared interferometry of circumstellar envelopes (e.g., Haniff et al. 1992; Tuthill et al. 1994), radio interferometry in molecular lines, both maser (Bowers et al. 1993) and thermal (Planesas et al. 1990). The results obtained suggest that many circumstellar envelopes have elongated shapes. This is also supported by variety of nonspherical structures (bipolar, elliptical) observed in planetary nebulae – descendants of AGB stars (Balick 1993). Several mechanisms can cause the asymmetry of mass loss: (1) stellar rotation (rather improbable for red giants, although plausible for absolutely younger red supergiants); (2) magnetic field; (3) star's nonradial pulsations; (4) presence of a companion star. Anyway, asymmetry in the shapes of planetary nebulae and their precursors – circumstellar envelopes – is laid early at the AGB stage. Viewing the lucky position of H_2O masers at the crucial levels of circumstellar matter acceleration, H_2O masers are useful tools for studies of mass loss asymmetries on the AGB. H_2O masers are strong and easily accessible for both interferometric and single–dish radio observations. Therefore, much information can be gained from systematic studies of circumstellar H_2O masers.

The most straightforward evidence for asymmetric geometry of circumstellar H_2O masers is got from interferometric (in particular, VLA and VLBI) observations. Circumstellar H_2O masers have been more than once studied interferometrically (Spencer et al. 1979; Lada et al. 1981; Johnston et al. 1985; Chapman and Cohen 1986; Lane et al. 1987; Reid and Menten, 1990; Bowers et al. 1993). Maps of distribution of circumstellar H_2O maser emission for the stars U Ori, W Hya, VX Sgr, VY CMa, R Aql, RR Aql, NML Cyg, IK Tau, RT Vir, RX Boo were obtained, for some of them (VX Sgr, W Hya, R Aql) – repeatedly. The maps show complex structure, with numerous spots of maser emission scattered in regions with sizes ranging between $\sim 10^{14}$ cm for giants and $\sim 10^{15}$ cm for supergiants. Shapes of visible distributions are in many cases far from circular. Generally, the authors of the above–mentioned works on H_2O interferometry are careful in their interpretation of the H_2O maps. However, in my opinion, the maps for at least two supergiant stars (VX Sgr and very much similar to it VY CMa) do show clear signatures of bipolar mass loss outflows.

In this contribution, I discuss only the case of the M–type supergiant VX Sgr, because the features of the bipolar model are most readily seen in this star. I show that even single–dish observations, if done systematically, can provide evidence for bipolarity in maser structure.

In my earlier work (Rudnitskij 1993), I considered a model of circumstellar masers with a circumstellar disc and a bipolar outflow directed along the disc axis. Here I apply this model to some more recent data on H_2O emission of VX Sgr.

Disc geometry is quite common in maser sources. Such a model was first suggested for masers in star–forming regions by Elmegreen and Morris (1979). A rotating disc of masering gas, when observed edge–on, produces a characteristic three–peak line profile with a central peak at approximately stellar radial velocity V_s and two satellite features arranged symmetrically with respect to V_s. Satellites come from disc's limb parts, while the central peak is generated in the gas moving perpendicular to the line of sight, at the near and far sides of the disc. Figure 1 shows an example of such a profile, observed in the H_2O maser emission of the M–supergiant VY CMa. Features coming from the disc are labeled with D's.

Proceeding from this, it is natural to assume that outflowing matter will be stopped by the disc in the equatorial plane, but will be free to expand in the polar directions, producing two oppositely directed flows. Figure 2 shows the geometry of the model. The maser emission from the disc yields a three–peak spectral pattern (as in Fig. 1) with some superposed features originating in the polar jets. I assume the masering gas to be concentrated at the walls of the two polar cones with opening half–angle

ϑ. Cones' axis is inclined to the line of sight at an angle i. Gas velocity along cones' walls is V_0. Such a model, when viewed at a moderate angle, produces two pairs of additional spectral peaks, shown on the model profile in Fig. 2. Probable corresponding features in the H_2O line profiles of VY CMa and VX Sgr are labeled with B's on Fig. 1 and 2. The picture described is supported by the H_2O interferometric maps of VX Sgr and VY CMa (Chapman and Cohen, 1986; Bowers et al. 1993), on which the disc and the jets can be distinguished, although these authors do not go such far in their interpretation of the data. The 'B' features can be seen on both H_2O profiles of VX Sgr, separated by almost ten years (Fig. 2), and, thus, are persistent structures, despite of the general flux variations.

Note that Likkel et al. (1992) came to similar conclusions on bipolar nature of H_2O masers in three evolved stars (probable planetary–nebula precursors) IRAS 16342–3814, W 43A, and IRAS 19134+2131. Likkel et al. also based upon single–dish H_2O observations. Thus, we can expect that repeated observations of maser line profiles for a number of late–type stars can help to reveal some long–living pairs of features that fit into the above model of circumstellar disc + bipolar flow. At present such a work on Pushchino H_2O data is in progress (for earlier results, see Berulis et al. 1983).

A complete set of our H_2O data on VX Sgr and VY CMa together with the details of the model will be published elsewhere (Berulis et al. 1996).

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GCVS: COMPLETION OF THE 4th EDITION AND PROSPECTS OF COMPUTER DATA BASE

N. N. Samus
Institute for Astronomy, Russian Acad. Sci.
48, Pyatnitskaya Str., Moscow 109017, Russia
E-mail: samus@airas.msk.su

ABSTRACT. The work of Moscow astronomers according to the IAU behalf on compilation of the General Catalogue of Variable Stars is reviewed. The 4-th edition is nearly finished. The last, 5-th volume of the Catalogue will contain information on nearly 11000 variable stars in other galaxies. Special attention is paid to work on more precise co-ordinates of the variable stars contained, to the prospects of the automatization of the work and creation of the user-oriented computer database.

Key words: Stars: variable.

The 4th edition of the General Catalogue of Variable Stars turned out to be an unlucky project. Since it had been commenced, two leading scientists and key organizers of the work, B.V. Kukarkin and P.N. Kholopov, died. The completion of the work was delayed, but now we are very close to its end. So it is time to review the stages of this work and to discuss prospects.

Before the World War II variable star catalogues were compiled in Germany. After the war, the IAU chose new groups of scientists to continue international projects earlier in German responsibility. So in 1946 the IAU decided to ask two groups of Soviet astronomers (in Sternberg Institute and in Variable Star Commission of the Academy of Science) to be responsible for compilation and publication of variable star catalogues.

The 1st edition of the GCVS was prepared very quickly (Kukarkin & Parenago 1948). Though German variable star catalogues appeared every year, the Soviet compilers decided to publish a new catalogue once in several years, and in between to publish supplements containing only stars for which the relevant information has changed significantly. Even the first announced interval between GCVS editions (5 years) was too short compared with reality; the 2nd edition appeared after a 10-year interval, the third edition was completed 13 years later, and the 4th edition is not yet ready now, 22 years after the completion of the 3rd one! The main reason is the greatly increased number of known variables: if the first catalogue published by the 'Astronomische Gesellschaft' (Prager 1926) had 2900 stars and the last one (Schneller 1942) contained 9476 variables, the first Soviet GCVS contained 10920 objects, and the 4th GCVS edition has 28435 entries for Galactic variables and will have 11000 stars — extragalactic variables — more. Modern developments in computer data bases give a hope to have a revised computer version of the GCVS very often (see below).

Two major steps had to be taken to start the 4th GCVS edition. First of them was the preparation of the New catalogue of suspected variables (NSV; Kholopov 1982). It was an important step in the GCVS modernization: the main table of the catalogue was computer generated, and a computer-readable version of the catalogue was prepared. The mentality of the compilers was still not ready for deep introduction of computers; they considered a book as the main product of their activity, and the computer version was a slightly modified version of the book, in a not sufficiently unified format and not quite easy to use at computers. This is a general problem with the 4th GCVS edition, but it became clear for us only at a later stage of its preparation (Samus& Kholopov 1985).

The NSV catalogue contains 14810 stars. A considerable fraction of these stars have now got final GCVS designations, and many new stars have been suspected. E.V. Kazarovets is now working on compilation of the supplement to the NSV catalogue.

The second step consisted in developing an updating the classification for variable stars. The basic contribution here was made by Kholopov (1983). The classification system described in the GCVS (Kholopov 1985) generally follows the same lines. This system is bulky (33 main types, with 70 subtypes in 14 of them) and not quite homogeneous (for example, the classification adopted for young irregular variables is additive — a type is the sum of symbols characterizing different properties, while for many other groups of variables a type is designated by the name of the prototype star). Probably this was the best system possible at that moment, but now it is necessary to reconsider it, maybe with wider use of the additive principle (see Samus 1992, and suggestions by E. Robinson in the discussion session following that talk).

By 1987, three Volumes of the 4th edition appeared. They contained information on variables of our Galaxy in all 88 constellations. It was planned that the next volume would be devoted to extragalactic variables. Preliminary work on it was done by P.N. Kholopov and N.M. Artyukhina. But after Prof. Kholopov's death on April 13, 1988, we had first to issue Volume IV (Reference Tables; Samus 1990), and only now we are practically ready with Volume V (Extragalactic Variables).

The main difficulty in the preparation of Volume V was in its astrometric aspect. The normal accuracy of co-ordinates in the main volumes of the GCVS is to 1s in right ascension and to 0.1' in declination. For external galaxies such co-ordinates are too rough. Though P.N. Kholopov did not want a different accuracy standard for one of the 5 volumes, we decided that to give better co-ordinates for extragalactic variables is absolutely necessary. The task of co-ordinate determination for thousands of them was undertaken by V.P. Goranskij. He actively used the possibilities connected with the GSC catalog. After this we found a number of earlier overlooked identifications of variables discovered by different authors, especially in the Magellanic Clouds.

The 5th GCVS volume will contain about 7200 stars in the Magellanic Clouds, 1200 stars in the Andromeda Galaxy, 600 stars in the Sculptor dwarf galaxy, 540 stars in M 33, and 1440 stars in other galaxies, the total about 10980 stars. We try to present for the majority of these variables the same information, including remarks, as in Volumes I – III. Now only variables in globular clusters remain outside the scope of the GCVS. To include also them, we need a principal decision of the IAU. The last Canadian catalogue of these variables was published 20 years ago (Sawyer Hogg 1973). It is also necessary to determine equatorial co-ordinates of variables in globular clusters: Sawyer Hogg's catalog gives only rough rectangular co-ordinates relative to cluster centers.

The magnetic tape versions of our catalogues now available contain only main tables of each volume. We have prepared magnetic tape versions of the remarks and reference lists; after necessary editing these files may also be presented to users.

The GCVS system includes the Name-lists of new variables. The 4th GCVS edition Name-lists Nos. 67 – 71 exist in printed form (IBVS) as well as in the computer readable form.

We have started a large scope astrometric work on variable stars, trying to be able in future to present co-ordinates of variables accurate at least to 1". Many variables can be identified with the Hubble Guide Star Catalog, but automatic identification leads to very high percentage of mistakes. So we try either to measure co-ordinate accurately on photographs (here we are actively assisted by Yu.A. Shokin of Sternberg Institute) or to check GSC identifications using published finding charts and the visualization software developed by V.P. Goranskij.

Since the beginning of the eighties, we have the understanding of the necessity of complete re-organization of our GCVS work, switching from the card catalogue to the computer data base. The volume of information contained in our card catalogue is estimated to be about 0.6 GBytes; several megabytes are added every year. The form of the coming information is highly inhomogeneous, its presentation in a format suitable for further use is not straightforward. A special system for handling variable star data has been developed (Fadeyev & Novikova 1989). It provides access to information contained in the data base through the so-called 'master list' (essentially the main table of the GCVS) and a system of key words. The system does work practically and shows the principal possibility of GCVS automatization. The limits to its everyday use are put by insufficient volume of data already in the data base, we have not yet started converting old data from our card catalogue to the computer readable form and are only able to input into the data base some 20% of newly arriving information on variable stars. And the limits to the rate of this work are put by the absence of a convenient 'envelope' program of data presentation in the necessary form and by insufficient computer park of our group. Nevertheless, we hope that our rich data base will sooner or later become available to every interested user having a computer. Then we shall be able to prepare computer versions of the main catalogue with much better regularity — and maybe even always have an updated version.

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AM HERCULIS IN 1989-93: VARIOUS TYPES OF PHOTOMETRIC AND POLARIMETRIC BEHAVIOUR

N. M. Shakhovskoy[1], I. L. Andronov[2], S. V. Kolesnikov[2]
[1] Crimean Astrophysical Observatory, Nauchny 334413 Crimea, Ukraine
E-mail: shakh@crao.crimea.ua
[2] Department of Astronomy, Odessa State University,
T.G.Shevchenko Park, Odessa 270014 Ukraine
E-mail: il-a@mail.ru

ABSTRACT. The types of variability of AM Her are discussed on the base of monitoring carried out at the 2.6m Shajn and 1.25cm AZT-11 telescopes of the Crimean Astrophysical observatory. The main types are the following: a) the wavelength–dependent regular variations with the orbital phase more pronounced in RI bands and observed at high and intermediate luminosity states; b) at the low and intermediate states the variations in UB which are usually in antiphase with RI; c) flares caused by the accretion events with colors close to that of the system; d) flares of the secondary of the UV Cet–type.

Key words: Stars: Cataclysmic Variables; Polars; AM Her.

The brightest polar AM Her was observed systematically in the Crimean Astrophysical Observatory since 1989. Mainly the object was observed in UBVRI bands simultaneously in photometric or polarimetric mode at 1.25 m telescope. Sometimes these observations were accompanied by measuring the circular polarization in V or wide R bands at the 2.6 m Shajn telescope. Altogether about 60 five–colors light curves and more that 40 polarization curves of AM Her were obtained. The preliminary analysis of these observations allows to distinguish the following types of photometric and polarimetric behaviour of this magnetic CV:

1. The regular variations with orbital period (1 and 2 harmonics) are dominating in the light curves in R and I bands at the *high* and *intermediate* brightness level of AM Her. The shapes of the light and polarization curves are very different. Usually the regular variations are accompanied by the irregular flares.

The colours of such flares are close to that of the system and they usually are pronounced in all bands (See Fig. 1-3). All data are plotted in the same scale for all bands. Phases are calculated by using the ephemeris by Aslanov et al. (1989) for the moment of the linear polarization pulse:

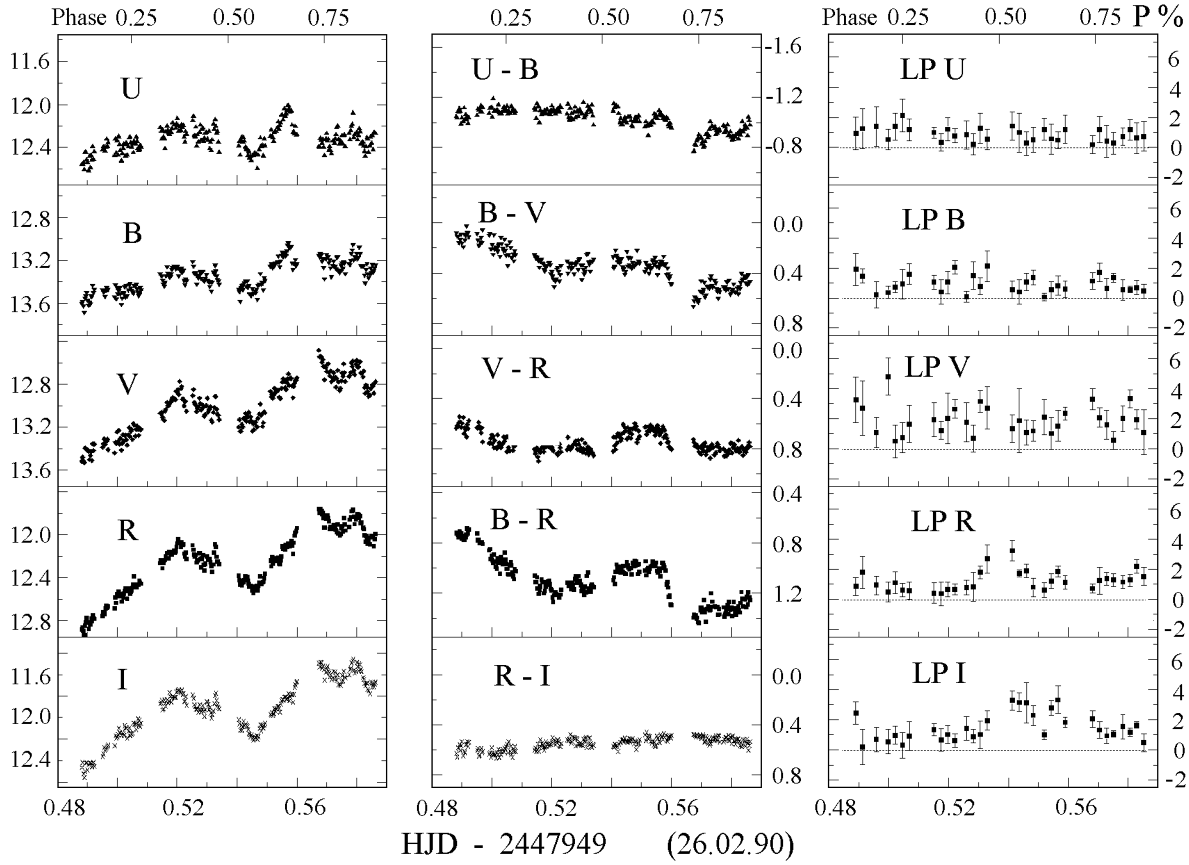
$$HJD_{max.pol} = 2443014.765 + 0.12892774 \cdot E.$$

The regular variations are better pronounced in the B–R colour because the contribution of flares are similar in different bands and thus are not seen in this colour.

The radiation of some (but not all) flares have the circular polarization in red bands. Circular polarization in R and I bands is usually negative.

Sometimes the reversal of sign of polarization was observed in V band at the time of the dips of polarization in red bands. In the U and B bands the polarization is small or absent. Evidently, the regular variations of brightness and polarization are connected with the changes of visibility of accretion columns with axial and orbital rotation; the "white" flares may correspond to the thermal and cyclotron radiation from separate "blobs" in the accretion flow.

The variations of the phases when circular polarization crosses zero may be interpreted by the changes of the orientation of the accretion column in respect to the rotating binary system both in longitude and latitude (Andronov



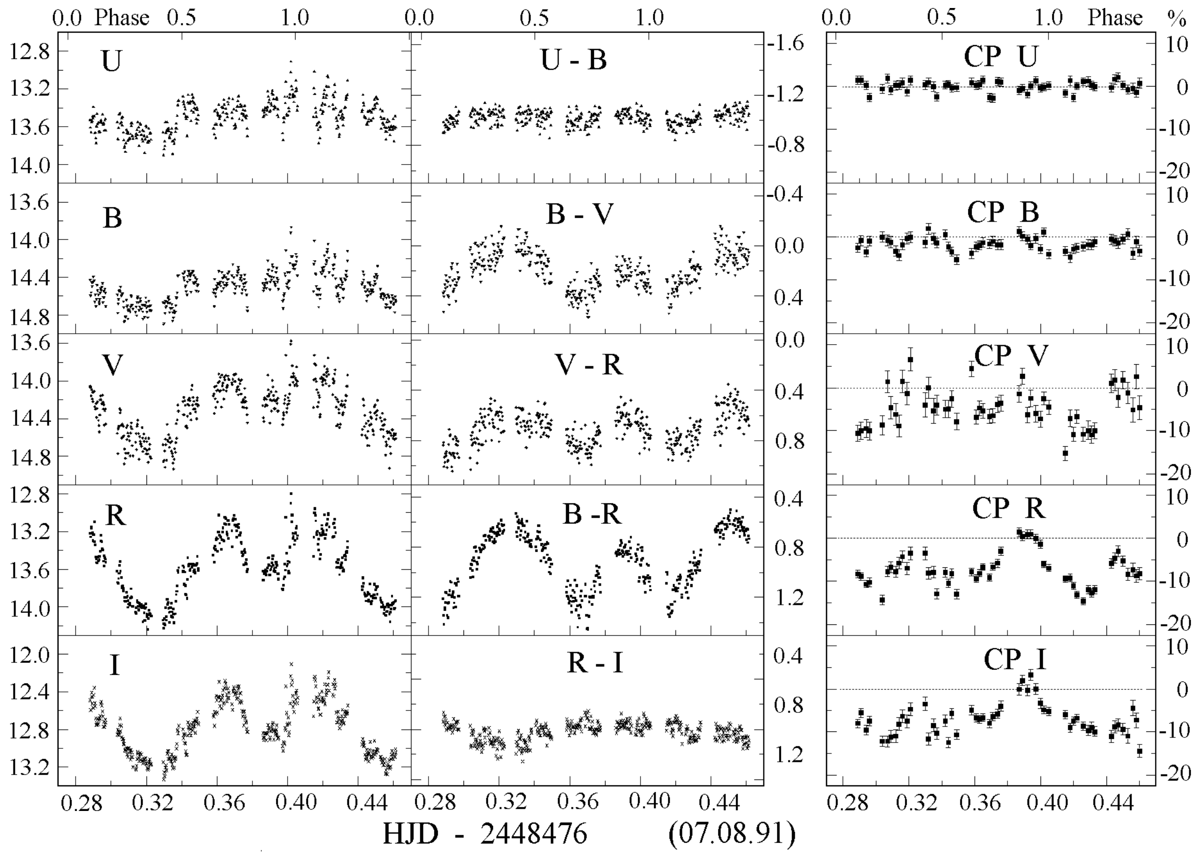
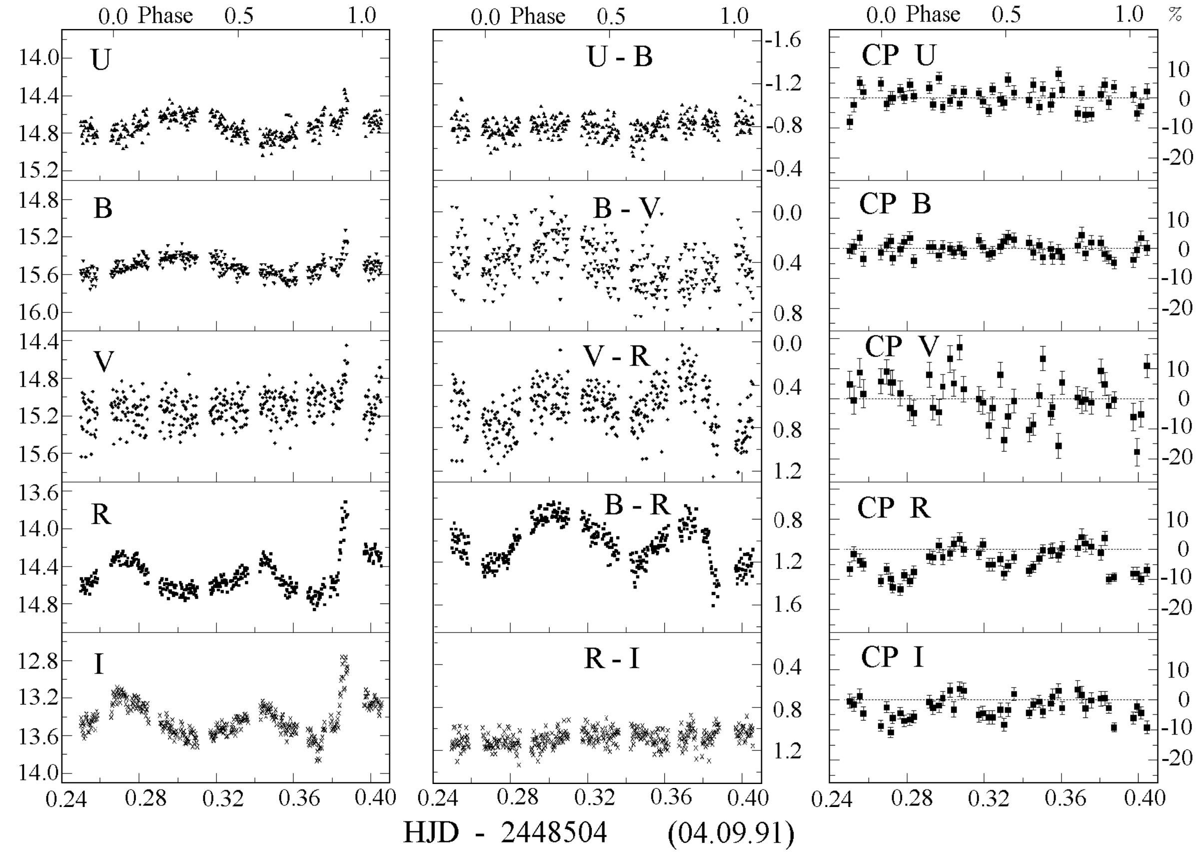


Figure 1 (Up): variations of magnitudes, colours and linear polarization of AM Her in UBVRI bands for 26.02.90.

Figure 2 (Bottom): The same but for circular polarization for 07.08.91.



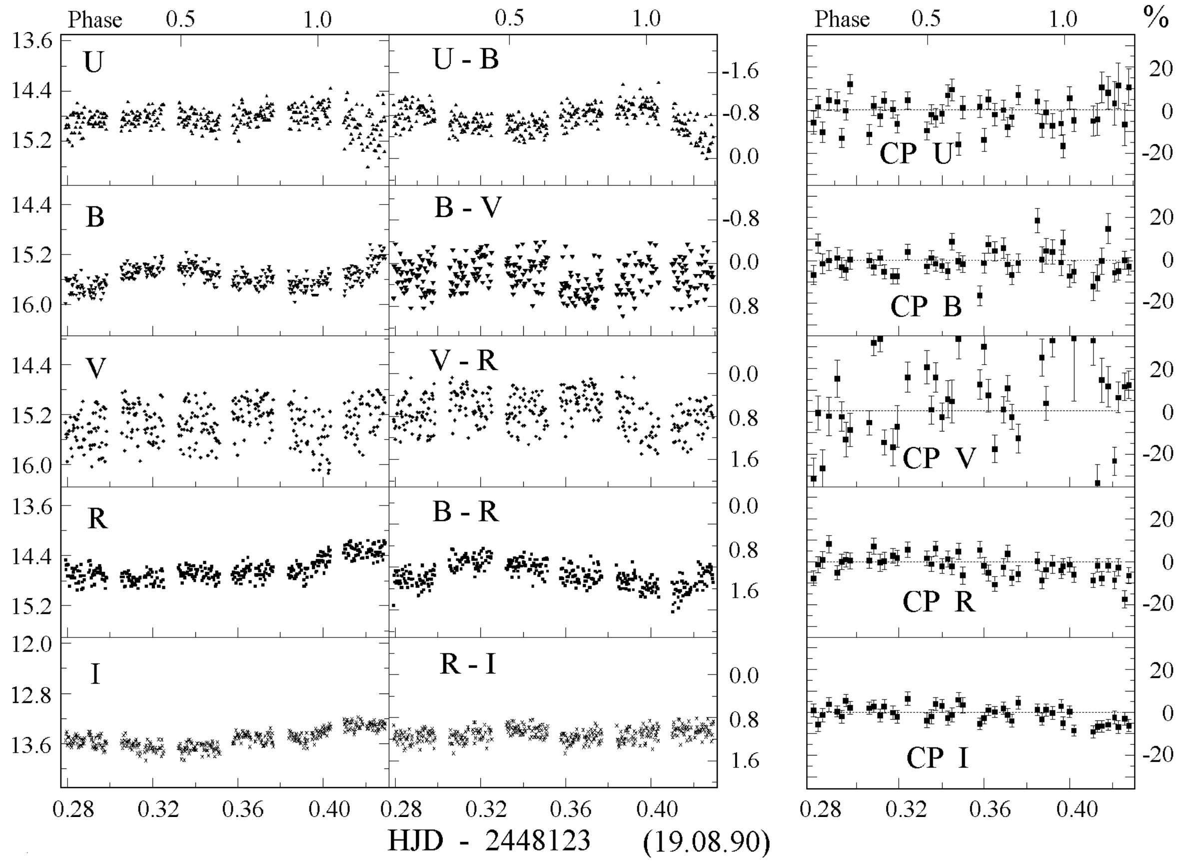
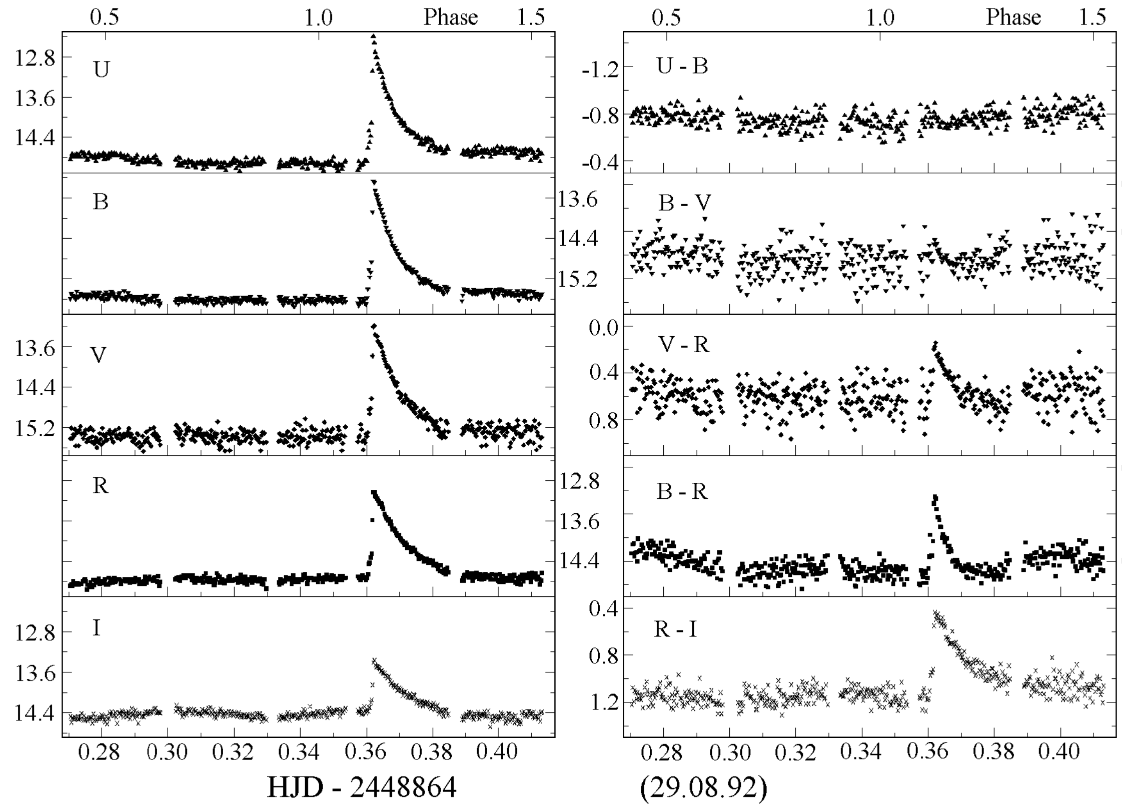


Figure 3 (Up): The same but for 04.09.91.

Figure 4 (Bottom): The same but for 19.08.90 - an extremely quiet state of AM Her.



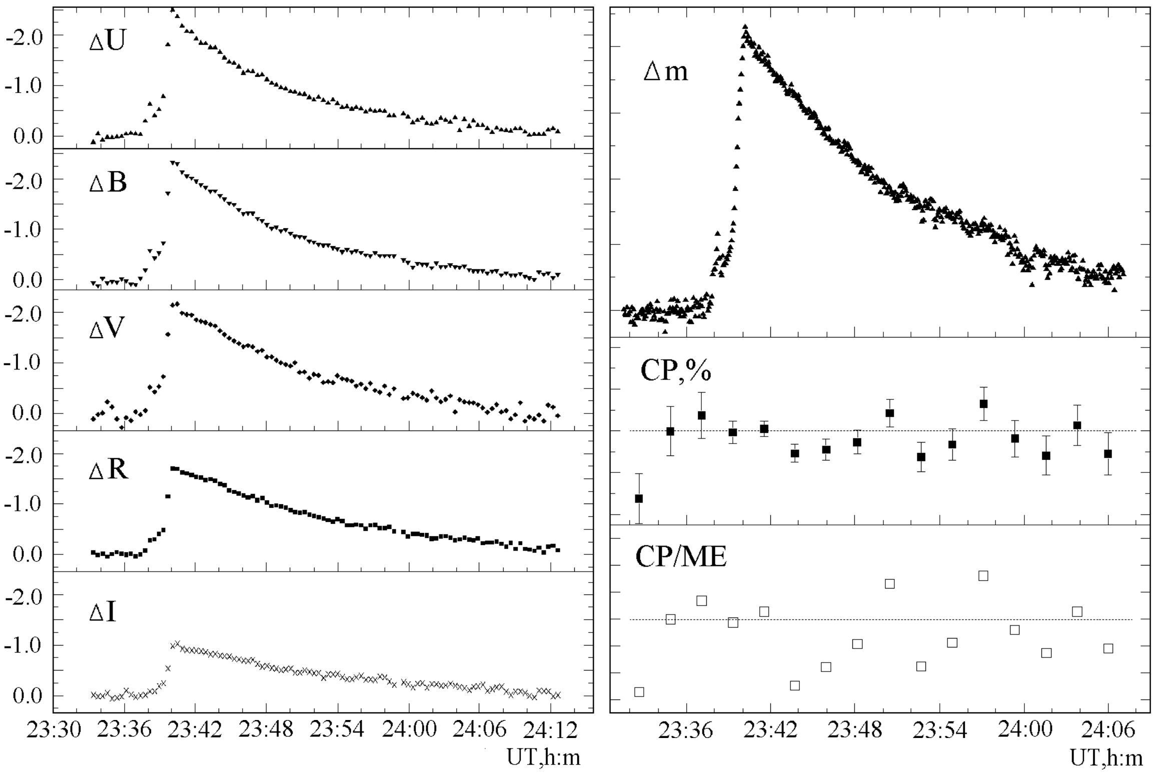


Figure 5 (Up): The light and colours curves of AM Her for 29.08.92 with strong blue flare.
Figure 6 (Bottom): The UBVRI light curves (left, 1.25m, $\Delta t = 12.5$s) and the brigthness and circular polarization in the wide R band (right, 2.6m, $\Delta t = 4$s) of flare 29.08.92.

et al. 1992) in agreement with the "swinging dipole" model (Andronov 1987).

The regular variations as well as the "white" flares may be completely absent at the extremely low levels of activity of AM Her (for instance, in July–August 1990 and in August 1992, when the circular polarization was absent, too). At this time the minute–scale variability (owed to accretion inhomogeneities) was practically absent (Andronov et al. 1992).

The mean power spectra of the runs of usual duration 8 min show a power law shape. The slope $\gamma = 1.28 \pm 0.10$ was maximal at the bright state 26.02.90 and close to zero $\gamma = 0.08 \pm 0.06$ and 0.20 ± 0.04 at low state 16.0890 and 19.08.90 (Andronov et al. 1992). The ACF analysis of the finite–length detrended data (Andronov 1994) allows to interpret the same data as the first–order autoregressive model with relative contribution to the variability increasing with mean brightness.

2. At the *low* or *intermediate* brightness level the smooth light variations (first harmonic of the orbital period) in U and B band are seen. Amplitudes of these variations are about 0.1–0.2 mag (Fig.3,4). Usually these variations are in antiphase with variations in R and I bands, but sometimes we have observed the another phase correlation between blue and red bands. This type of changes of brightness may be possibly explained by the reflection of light from the accretion columns or white dwarf by the secondary component of the binary system or with inhomogeneity of the surface of secondary (spots?).

3. Several "blue" flares were observed at the *low* state of brightness. The strongest flare of this type was recorded on August 29, 1992. At this night AM Her was at the extremely low and quiet state with V=15.40. Observed amplitudes of the flare in the UBVRI bands were 2.54, 2.36, 2.14, 1.71 and 0.84 mag, respectively. The rising time of flare was about 3 min and the time of full descending - about 30 min (Fig.5,6). One may also see a pre–flare of smaller amplitude. The shapes of the flare light curves and the intrinsic colours of flare radiation are very similar to the same characteristics of the strong flares on red dwarf stars of UV Cet type (Alexeev et al. 1994). The polarization in this flare was absent too, as well as during the flares of UV Ceti stars (Alexeev et al. 1994). At the maximum of the AM Her flare its intrinsic colours were similar to the colours of the blackbody radiation with T=12,000 K (Fig.7). The dimension of the radiating source estimated from its energy for the blackbody approximation is $\approx 10^{19}$ cm^2. This value is close to the area of the DA white dwarf disk. The full energy of the AM Her flare observed 29.08.92 in optics lies near the upper limit for the energy observed for the flares of red dwarf stars. We conclude that the giant flare 29.08.92 as well as some fainter blue flares of AM Her originated on the secondary red component of binary system – the M4.5 dwarf (Shakhovskoy et al. 1993).

In the case of AM Her the surface of the secondary lies inside the magnetosphere of the primary, and the strength of primary's magnetic field at secondary must be larger than the intrinsic secondary's photospheric fields. Nevertheless all observed characteristics of the flare in AM Her are very similar to those for flares of single red dwarf stars.

Acknowledgements. Some observational runs in UBVRI were obtained by D.N.Shakhovskoy, I.Yu.Alexeev, A.V.Berdiugin and E.S.Dmitrienko.

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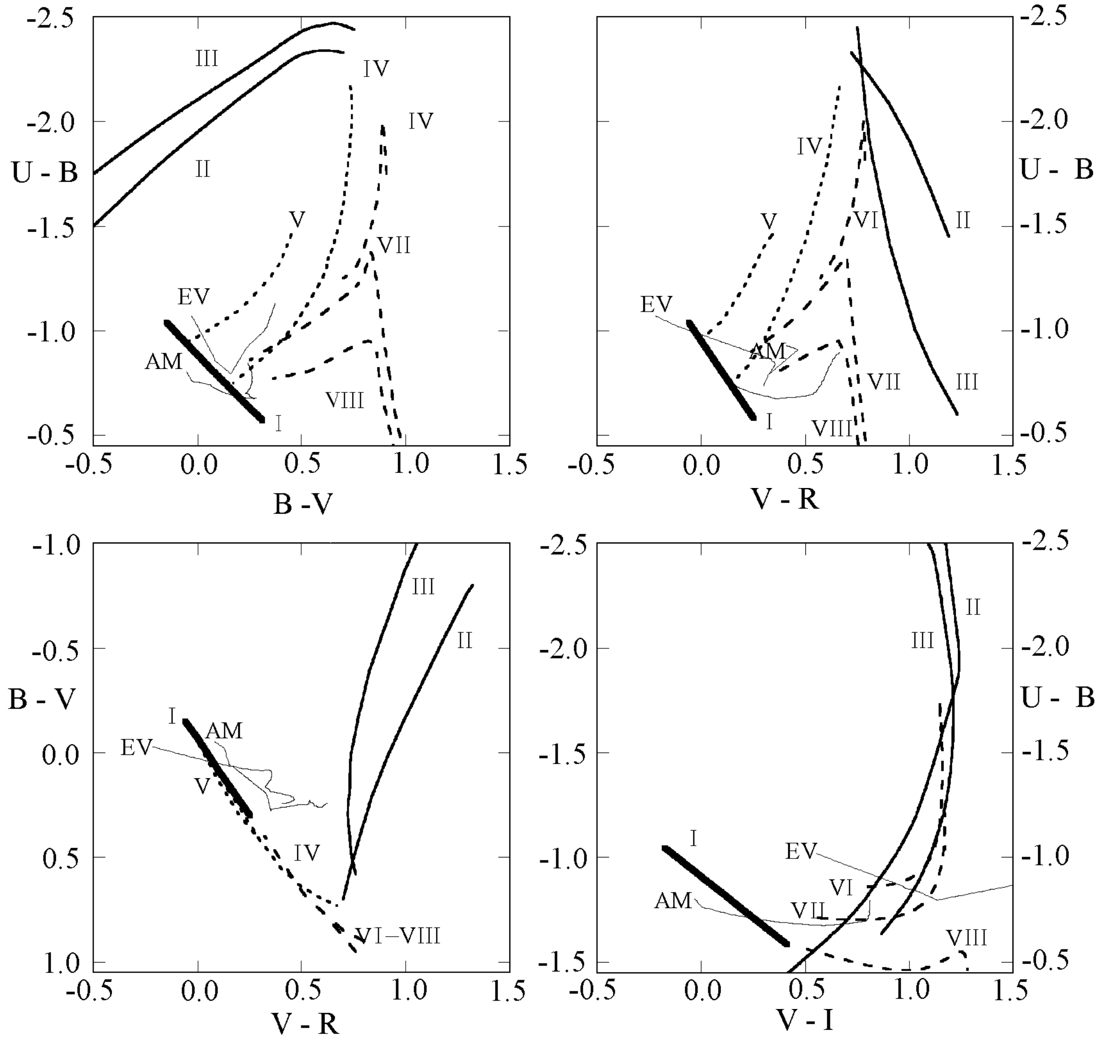

Figure 7: The two-colour diagramms for the flares of AM Her, EV Lac and for different theoretical models of the flare radiation from Alexeev et al. (1994) and Abdul-Zade et al. (1995). The legends are:
AM – track for the flare of AM Her on 29.08.92.;
EV – track for the flare of EV Lac on 15.09.91.
I – black body (temperature from 6,000 to 20,000 K),
II – optically thin hydrogen plasma with T_e =10,000 K, $n_e = 10^{12}\mathrm{cm}^{-3}$.
III – –”–, $n_e = 10^{14}\mathrm{cm}^{-3}$.
IV – optically thick plasma, T_e =10,000 K. V – –”– T_e =15,000 K.
VI – the photosphere of the red dwarf heated by the proton flux with $E = 1$ MeV.
VII – –”–, $E = 3$ MeV. VIII – –”–, $E = 5$ MeV.

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V.P.TSESSEVICH - A SCIENTIFIC SUPERVISOR OF THE ODESSA OBSERVATORY EXPEDITION ON THE DETERMINATION OF LATITUDE AND LONGITUDE FOR BTA POSITION SITE

M. Yu. Volyanskaya, O. E. Mandel, Yu. D. Russo
Astronomical Observatory, Odessa State University,
T.G.Shevchenko Park, Odessa 270014 Ukraine
E-mail: root@astro.odessa.ua

ABSTRACT. In the paper one from little known pages of Prof. V.P.Tsessevich' life and scientific activity as an organizer and scientifics supervisor of expedition on the determination of coordinates of site, where BTA would be placed, is described. V.P.Tsessevich have formed a staff of expedition, scientific problems and have taken direct part of the first and final stages of the expedition. As a result of expedition coordinates which corresponded to requirements of astroplace of the second class (expeditionary) have been obtained and axes of BTA have been traced on the locality.

Key words: coordinates, astroplace, organization of expedition.

In his versatile activities, V.P.Tsessevich exerted special efforts and contributed much to creating new astronomical institutions. He took a direct part in the founding of Abastumani and Dushanbe observatories, GAO (Main Astronomical Observatory) of the Academy of Sciences of the Ukrainian SSR, of observing stations at the Odessa Observatory, promoted to arranging and equipping observatories in a number of Pedagogical Institutes, in Kherson Naval College, in some secondary schools as well as in the Planetaria organizations. For grounding of organizing each of the above institutions these of those scientific problems were put forward (for example, provision for long-term continuous series of observations of short-periodic or flare variable stars, basis meteor observations etc.); some years elapse and it becomes as clear as noon day that V.P. used to be immensely glad of and feel great satisfaction with the mere fact of every astronomical observatory inauguration and his personal participation in it. The reason of it may lie in the obvious truth that a real scientist gets satisfied subconsciously with raising intellectual level of the ambient community. Personal contacts in his youth with such outstanding astronomers as S.P.Glazenap, A.Ya.Orlov and others are certain to have affected it, too.

Therefore, when in April 1965 O.B.Vasilyev, Director of an observatory under construction SAO (Special Astronomical Observatory, Academy of Science of the USSR), requested V.P.Tsessevich for rendering help in the determination of precise coordinates for future BTA position, V.P. immediately gave a ready consent. The expedition was suggested to be headed by B.V.Novopashennyi, a well-known Odessa astrometrist, highly experienced in astronomical and geodetic observations. The thing is that the unusual construction of the BTA-set (an alt-azimuthal type for a large telescope is a unique design) required high precision in laying out construction lines of the site to provide necessary directions of channels for light beams. The suggested project requirements were with corresponded to the determination of the astroplace as that of the second class (expeditionary). V.P.Tsessevich had to pluck certain courage of taking the decision for such works used to be carried out practically in monopoly under the aegis of GUGK USSR, and the results since some time were considered as secret ones. The coordinates of our observatories, if it necessary, were taken from foreign Year-books, so the execution of the work like that could have been fraught with some consequences.

It was high time for the direct construction works to be started at the Semirodniky Mount not far from Zelenchukskaya stanitsa in the Northern Caucasus, however precise position of the BTA site was not known yet. The geodetic authorities to whom future SAO administration had appealed made doubts the dates of realization this work as well as of reduction for astronomical refraction under high altitude conditions. In May 1965 O.B.Vasilyev sent a telegram to V.P.Tsessevich asking for the expedition to arrive immediately and promising on his part to do all preparatory work and settle all the organizational problems. Suddenly it turned out that B.V. Novopashennyi was unable to participate in the expedition because of his poor state of health. Nevertheless, V.P.Tsessevich did send an expedition which included the then quite young specialists - the authors of the present information. It is worth remembering that there was little experience in a total volume astroplace's determination among the expedition participants though they possessed some certain skill in astrometrical observations (e.g. observations with an universal instrument and the meridian circle, the work at the AES observational station). And it was there that one of Tsessevich's merits was fully manifested, and namely his firm belief of his colleague's competence and capacities, in their capabilities of which they themselves hardly suspected, as well as his own ability of taking responsibility for young specialists' activity and conduct - it was at our request that V.P.Tsessevich headed the expedition.

In early June the expedition of four people went by air to Mineralnye Vody. The equipment comprised a 5" universal instrument "Aerogeopribor" No.1302 (it was carefully checked up by the mechanic A.A.Podlubny beforehand) and an apparatus for providing time service which was used at the AES station No.073, Odessa. Unfortunately, despite of all mechanic's efforts exerted we failed to completely get rid of some instability in the vertical axle of universal instrument. Due to this, the quantity of observed Zinger's and Talkott's pairs had to be increased for providing necessary precision of results. At the Minvody airport we were met by O.B.Vasilyev and the scientific supervisor of SAO, O.A.Melnikov at that time. After a short talk the latter left for Pulkovo. Having climbed up the mountain we found out the future BTA site to have been quite untouched by human beings' activities. And the highway engineering was only under way, the road reached only the place of today's RATAN position. In the Mount itself there stood a small sheep-fold wherein two herdsmen lived and were busy grazing bull-calves, rather frisky ones. O.B.Vasilyev arranged delivering a small carriage as "spacious" as one sleeping compartment to the Mount as well as a small local power station working on petroleum only and a barrel of petroleum. At the very place a stone tomb was built for observations with the universal instrument; whereas to guarantee observers' safety against too curious animals we were given a document signed by the kolkhoz chairman testifying to the fact that the cattle was prohibited to pasture there. In case of emergency we were handed a gun which we had to use several times for getting food. After solving some technical and organizational questions jointly with O.B.Vasilyev and being convinced of the possibility of starting the expedition work V.P.Tsessevich left for Odessa having promised to come back by the completion of observational work to put documents in order.

On June 20th 1965 observations were started. A report devoted to the scientific aspect of the matter is presented to Russia astrometrical conference (October 1993, Pulkovo) at the section "Applied problems of astrometry". It should be noted here only that within 9 nights suitable for observations, through July 9th, 28 determinations of latitude were done from the Polar star altitudes (an approximate method), observations were made of 43 Zinger's pairs for determining longitude and of 24 Talkott's pairs for precise determining latitude. Besides, the astronomical azimuth of a stone pyramid which was built by the expedition participant at the mark of 2059.6 m (near the BTA center) was determined by 8 total methods from the Polar and by 7 total ones by the Sun. A number of auxiliary angular measurements were made and the azimuth of BTA center determined.

The observations were carried out by M.Yu. Volyanskaya, the observational programs and reductions were made by M.Yu.Volyanskaya and O.E.Mandel, where as time service was conducted by Yu.D.Russo. For registered time, the standard equipment of No.073 station of AES photographic observations was used incorporating a receiver of PRV–type, pulse adapters IP–1 and IPM, a quartz printing chronograph ECL. For determining a zero–point of chronograph, RVM–signals were received (5 MHz, Moscow). The results of the work were handed to the head of LO GIPRONII, Academy of Sciences of the USSR, G.D.Vsesvietsky (on the Act) jointly with whom the axes were traced on the place. It was also he who together with engineers of SAO, which was being built then, carried out the laying out of BTA axles on the plane.

The final stage of the work was performed with V.P.Tsessevich's participation, his signature remaining in the corresponding documents. The expedition returned to Odessa but soon went to Nikolaev observatory (main longitude point) for determining personal equation of observer. After final reduction of observational results, latitude and longitude data of SAO, Ac.Sc.USSR were given to the SAO authorities. On returning to Odessa one of the participants remarked jokingly addressing V.P.Tsessevich, "So, Professor, are you going to change your profession of an astrophysicist for that of an astrometrist?" Vladimir Platonovich responded to this seriously:"I'm asking you not to forget that in my diploma it is written that I am Professor of Astronomy". Indeed, Vladimir Platonovich was a great specialist in all the fields of astronomy, a real PROFESSOR of our wonderful science.

(MULTI–) FREQUENCY VARIATIONS OF STARS. SOME METHODS AND RESULTS

I.L. Andronov
Department of Astronomy, Odessa State University
T.G.Shevchenko Park, Odessa 270014 Ukraine
E–mail: il-a@mail.ru

ABSTRACT. Some algorithms and programs are described for determining the parameters of processes with constant and variable periods. Those are: FOUR-1 – periodogram analysis by using the least squares one–harmonic fit, FOUR-N corresponds to a number of harmonics, FOUR-T to a sine wave with a linear trend, FOUR-M to a number of waves with independent frequencies. Multishifted and mean weighted periodograms are discussed. PERMIN allows the determination of a best fit period from the moments of "characteristic events" only. The programs allows one to determine not only the parameters, but accuracy estimates and the "false alarm" probability as well. Some applications of these and some other methods to variable stars of different types are discussed.

Key words: Data reduction, Stars: binary, multiple, pulsating

Basic Equations

Although the method of the least squares is widely used (e.g. Whittaker and Robinson 1926, Anderson 1958), we briefly summarize the basic equations in the notation used for the applications below.

In general, the system of normal equations corresponding to the method of least squares may be written as

$$\sum_{\alpha=1}^{m} A_{\alpha\beta}\, C_\alpha \;=\; B_\beta, \qquad (1)$$

$$A_{\alpha\beta} \;=\; \sum_{k=1}^{n} f_\alpha(z_k)\; f_\beta(z_k), \qquad (2)$$

$$B_\beta \;=\; \sum_{k=1}^{n} x_k\; f_\beta(t_k)$$

and the coefficients $C_\alpha, \alpha = 1...m$ depend on the observations (x_k obtained at moments t_k as well as on the shape of the basic functions $f_\alpha(t)$.

Root mean squared error σ of the smoothing function

$$x_c(t) = \sum_{\alpha=1}^{m} C_\alpha f_\alpha(t) \qquad (3)$$

and its derivatives of the s^{th} derivative with respect to the parameter t may be determined as

$$\sigma^2[x_c^{[s]}(t)] = \sigma_*^2 \sum_{\alpha\beta=1}^{m} A^{-1}_{\alpha\beta} f_\alpha^{[s]}(t) f_\beta^{[s]}(t), \qquad (4)$$

where σ_*^2- is the "unit weight" error. The mathematical expectation of it is equal to

$$\sigma_*^2 = \frac{1}{n-m} \sum_{k=1}^{n} (x_k - x_c(t_k))^2, \qquad (5)$$

and $A^{-1}_{\alpha\beta}-$ is the matrix, inverse to $A_{\alpha\beta}$.

The moment of extremum t_e is a root of the equation $x_c^{[1]}(t_e) = 0$. An estimate of its r.m.s. value is

$$\sigma[t_e] = \frac{\sigma[x_c^{[1]}(t_e)]}{|x_c^{[2]}(t_e)|}. \qquad (6)$$

These expressions may be generalized for the case when the smoothing function depends on additional parameters D_γ, $\gamma = 1...p$. One may choose initial values and then determine differential corrections by using the system of equations

$$\sum_{\alpha=1}^{m} f_\alpha(z)\,\delta C_\alpha + \sum_{\gamma=1}^{p} \frac{\partial x_c}{\partial D_\gamma}\,\delta D_\gamma = x_k - x_c(t_k). \tag{7}$$

After iterating one may determine the $m+p$ parameters C_α, δD_γ and corresponding error estimates. Obviously, the derivatives

$$\frac{\partial x_c(t)}{\partial D_\gamma} = \sum_{\alpha=1}^{m} C_\alpha \left(\frac{\partial f_\alpha(t)}{\partial D_\gamma}\right)_{t\,=\,t_k} \tag{8}$$

may be determined by using coefficients C_α, determined from the m normal equations for fixed values of D_γ.

In other words, in the linearized model (7) one may formally write $\delta C_{m+\gamma} = \delta D_\gamma$ and $f_{m+\gamma} = \partial x_c(t)/\partial D_\gamma$ (computed according to Eq. (8)) suggesting that the number of the unknowns is $m' = m + p$. Error estimates may be computed similar to Eq. (4–6). It is important to point out that the error estimates of the coefficients C_α obtained from the models with m and $m+p$ unknowns are generally *different.*

In the least squares methods one compares the variance of the residuals with that of the initial observations. Thus as a basic function, we have used the statistics

$$S(f) = \frac{\sigma_C^2}{\sigma_O^2} = 1 - \frac{\sigma_{O-C}^2}{\sigma_O^2}, \tag{9}$$

where σ_O is the r.m.s. deviation of the "observations" O from the sample mean. C corresponds to "calculated" values and $O-C$ to the deviations of the "observed" values from the "calculated" ones.

If the values x_k are normally distributed, with the same mean and variance, uncorrelated random data (hereafter "random"), then the random variable S has a B-distribution

$$\rho(S) = \frac{\Gamma(\mu+\nu)}{\Gamma(\mu)\,\Gamma(\nu)}\, S^{\mu-1}\,(1-S)^{\nu-1} \tag{10}$$

(cf. Mardia and Zemroch 1978) with parameters $\mu = n_1/2$, $\nu = n_2/2$, where n_1 is the number of additional degrees of freedom used for the fit as compared with that used for determination of σ_O. The mathematical expectation of the mean value is $<S> = \mu/(\mu+\nu)$.

A brief discussion of the period search methods with application to some programs described here was presented by Andronov (1991a). A more detailed review and list of references is given in Andronov (1995).

One–harmonic fit (FOUR–1)

The model is

$$x_c(t) = C_1 + C_2 \sin\omega t + C_3 \cos wt, \tag{11}$$

thus the values of the basic functions at arguments t_k are $f_1(t_k) = 1$, $f_2 = \sin(\omega t_k)$, $f_3 = \cos(\omega t_k)$. Here $\omega = 2\pi f$, where f is trial frequency.

The "true" least squares fit (11) differs from the widely used approximations by Deeming (1975) and Lomb (1976).

To determine σ_0 one uses $n-1$ independent variables with the mean subtracted. For the one–frequency model two additional parameters C_2 and C_3 are determined, thus the number of the degrees of freedom are $n_1 = 2$ and $n_2 = n - 1 - n_1 = n - 3$ (cf. Andronov 1991):

$$\rho(S) = \frac{n-3}{2}(1-S)^{(n-5)/2} \tag{12}$$

with a corresponding mean value $<S> = 2/(n-1)$ The probability $Pr_1 = \mathrm{Prob}(S > S_0)$ of $S > S_0$ is equal to

$$Pr_1 = \int_{S_0}^{1} \rho(S)dS = (1-S_0)^{(n-3)/2}. \tag{13}$$

It may be noted that this expression differs significantly from the approximation $Pr_1 = \exp(-S_0/ <S>)$ (e.g. Scargle 1982) which is usually used. This approximation in fact corresponds to the χ_2^2-distribution. However, the χ^2-approximation may be used only if one knows the general variance of the observations σ^2. The estimate σ_O^2 is used instead for the definition of $S(f)$. Thus the statistically justified distribution for the case of random normally distributed observations is described by the expressions mentioned above.

For many frequencies one has to estimate a "false alarm" probability

$$Pr = 1 - (1 - Pr_1)^K, \tag{14}$$

(Scargle 1982, Terebizh 1992) where K is the number of "independent frequencies" which may be estimated for n observations which are nearly equidistantly distributed in time as $K \approx (f_{max} - f_{min})/\Delta f$, where $\Delta f = n/((n-1)(t_n - t_1))$ for observations equidistantly distributed in time.

The spectral window is computed as

$$S_w(f) = \left(\frac{1}{n}\sum_{k=1}^{n}\cos\omega t_k\right)^2 + \left(\frac{1}{n}\sum_{k=1}^{n}\sin\omega t_k\right)^2 \quad (15)$$

(cf. Deeming 1975, Terebizh 1992). It is equal to unity for $\omega = 0$ and must be close to zero for "good" (nearly equidistant in time) observations. If the signal contains periodic components with frequencies f_{0j} and the spectral window has peaks at frequencies f_{wi} then a number of "alias" peaks at frequencies $|f_{0j} \pm f_{wi}|$ may be seen.

One may note that the periodograms of real observations often obey a power law: $S(f) \propto F^{-\gamma}$ indicating correlations between the subsequent data. For infinite data with "white noise" $\gamma = 0$, or "flicker noise" $\gamma = 1$, and for "random walks" $\gamma = 2$ (Terebizh 1992). Influence of the finite length of data runs on periodogram shapes is discussed by Andronov (1995). The power laws may be produced by several mechanisms – e.g. fractals, autoregressive processes, slow trends, and non-coherent oscillations.

The program FOUR–1 is arranged in the following way. First input file with 7 guidelines contains:

1. File name with the input data in a free format: two columns t_k, x_k separated by a blank space.

2. Output file 1 – results of the periodogram analysis determining the highest peak by using the differential corrections and describing all the peaks by fitting them by a parabola.

3. Output file name 2 - periodogram containing the columns: frequency, $S(f) + 0.6$, $S_w(f)$. Such format is convenient for drawing a periodogram using graphic editors. The arbitrary shift 0.6 is included to show in the same figure both the periodogram and the spectral window.

4. First trial frequency f_1.

5. Frequency step $\Delta f = \eta/(t_n - t_1)$ with $\eta \approx 0.10$ (cf. Kholopov 1971).

6. Number of trial frequencies.

7. Output file containing two columns with t_k and $x_k - x_c(t_k)$. One may use this file to compute a periodogram for these "prewhitened" $(O - C)$ observations.

The program is "non–stop", i.e. after finishing computation of the periodogram it reads from the file next 7 guidelines and starts again.

Multi–Harmonic Fit (FOUR–N)

For one–frequency signals with a complicated shape one may use basic functions ($f_1 = 1$, $f_{2j} = \sin(j\omega t)$, $f_{2j+1} = \cos(j\omega t)$, $j = 1...s$). For random data the number of degrees of freedom is $n_1 = 2s$, $n_2 = n - 1 - 2s$. After preliminary determination of the best-fit frequency one may use the method of differential corrections with

$$f_{2s+2}(t) = t\sum_{j=1}^{s}(C_{2j}\cos(j\omega t) - C_{2j+1}\sin(j\omega t))j. \quad (16)$$

An error estimate $\sigma[\omega] = \sigma_* \cdot (A^{-1}_{2s+2,2s+2})^{1/2}$. Obviously, $\sigma[f] = \sigma[\omega]/(2\pi)$ and $\sigma[P] = \sigma[f] \cdot f^{-2}$.

The problem is to choose an adequate number of harmonics s. In our program we choose the maximal number s_0 (usually 4–5) and compute periodograms for all $s \le s_0$. Than we choose a preliminary value of the frequency and use the method of differential corrections. If one will plot a $\sigma_*(s)$ diagram, one may see that σ_* decreases with s for small s and then it is nearly constant within error estimates. Thus one method is to determine the number s, after which the significant decrease of σ_* stops (cf. Terebizh 1992). One may compute the parameter

$$V_s = \frac{(n - 2s + 1)\sigma_*^2(s-1)}{(n - 2s - 1)\sigma_*^2(s)} - 1 \quad (17)$$

which (for random data) has the Fischer distribution with 2 and $(n - 2s - 1)$ degrees of freedom (cf. Mardia and Zemroch 1978). Thus one may choose a confidence level and determine s in the interval from 1 to s_0.

The r.m.s. value of the error estimate σ_{obs} of the smoothing function at the times of observations is defined as

$$\sigma^2_{obs} = \frac{\sigma^2_*}{n} \sum_{k=1}^{n} \sum_{\alpha\beta=1}^{m} A^{-1}_{\alpha\beta} f_\alpha(t_k) f_\beta(t_k) = \frac{m}{n}\sigma^2_*. \quad (18)$$

To minimize the statistical error of the smoothing curve, one has to choose m minimizing the right side of this equation. However, for noisy signals, the value of σ_* decreases with m not very fast, thus one may formally prefer to use one–harmonic fit or even a constant mean value.

The same problem occurs for minimizing the r.m.s. error estimate σ_{phase} of the smoothing function at all phases:

$$\begin{aligned} \sigma^2_{phase} &= \sigma^2_* \cdot \frac{1}{P} \int_0^P \sum_{\alpha\beta=1}^{m} A^{-1}_{\alpha\beta} f_\alpha(t) f_\beta(t)\, dt = \\ &= \sigma^2_* \left(A^{-1}_{11} + \frac{1}{2} \sum_{\alpha=2}^{m} A^{-1}_{\alpha\alpha} \right). \end{aligned} \quad (19)$$

Contrary to the error estimate of the moment of extremum (Eq.(6)), the error estimate $\sigma[U]$ of the asymmetry of the light curve defined as $U = (t_{max} - t_{min})/P$ may be computed by using the more complicated expression

$$\sigma^2[U] = P^{-2} \sigma^2_* \sum_{\alpha\beta=1}^{m} Z_\alpha Z_\beta \quad (20)$$

Here $Z_\alpha = z(t_{max}) - z(t_{min})$ and

$$z_\alpha(t) = -\frac{\dot{f}_\alpha(t)}{\sum_{\varepsilon=1}^{m} C_\varepsilon \ddot{f}_\varepsilon(t)} \quad (21)$$

For multiharmonic fit, $z_1(t) = 0$,

$$\begin{aligned} z_{2j}(t) &= -j\cos(j\omega t)/(wY) \\ z_{2j+1}(t) &= j\sin(j\omega t)/(wY) \\ Y &= \sum_{j=1}^{s} j^2 (C_{2j}\sin(j\omega t) + C_{2j+1}\cos(j\omega t)) \end{aligned} \quad (22)$$

Multi–Frequency Fit (FOUR–M)

The basic functions are $f_1(t) = 1$, $f_{2j}(t) = \sin(\omega_j t)$, $f_{2j+1}(t) = \cos(\omega_j t)$, $j = 1...s$. For preliminary determination of the frequencies one may compute a grid of models with different combinations of the values of ω_j with frequency steps defined as for one–frequency models. The test function $S(f_1, ..., f_s)$ for random observations obeys $B-$ distribution with $\mu = s$ and $\nu = (n-1-2s)/2$. For more precise determinations of the parameters one may use the method of the differential corrections, so

$$f_{2s+1+j}(t) = (C_{2j}\cos(\omega_j t) - C_{2j+1}\sin(\omega_j t))t. \quad (23)$$

An alternate method is "prewhitening" (e.g. Terebizh 1992), in which one frequency models are applied to the initial observations. Then the best fit is subtracted from the data, the periodogram is recomputed for the residuals, the new wave is subtracted etc. This method is useful for preliminary determination of the frequencies. However, the method of differential corrections allows the determination of all the frequencies correctly.

A popular program to determine parameters of the multi–harmonic and multi–frequency fits was published by Breger (1990). Our program allows also one to obtain the corresponding error estimates.

An example of application of this code to the semiregular variable RX Boo was published by Andronov and Kudashkina (1988b).

Multi–Shift Fit (FOUR–S)

Such a model may be applied if the observations are subdivided into r separate runs and there may be run–to–run changes owed to the long–term variations of the object. Also there may be small shifts between the instrumental systems if the runs were obtained in different observatories.

The basic functions are the following: $f_\alpha(t_k) = 1$, if the observation belongs to the α^{th} run and 0 else. Other basic functions are sines and cosines similar to the discussed above. If the number of the frequencies used is s than $m = r + 2s$ and the parameters of the $B-$distribution are $\mu = s$ and $\nu = (n - r - 2s)/2$.

This model was applied e.g. for 2–frequency fits of 15 runs of the cataclysmic variable TT Ari (Tremko et al. 1992) taking into account different weights of the individual observations.

Mean weighted periodograms

The mean weighted test function $S(f)$ calculated from the values S_i corresponding to the season No. i and the given trial frequency, by using the expression

$$S(f) = \frac{1}{n\sigma_O^2} \sum_{i=1}^{q} n_i \sigma_{Oi}^2 S_i(f),$$
$$n\sigma_O^2 = \sum_{i=1}^{q} n_i \sigma_{Oi}^2, \quad n = \sum_{i=1}^{q} n_i. \qquad (24)$$

where n_i is the number of observations in the i^{th} season, and σ_{Oi}^2 - is the variance in the same run. This model (24) takes into account the possibility that the variations of the mean brightness a_i occur, as well as the amplitude and the initial phase. The variations of the values σ_{Oi} are assumed to be attributed to the apparent random changes from run to run, but the general dispersion σ_0 is the same for all q runs. For random data the test function $S(f)$ has the "B−type" probability distribution function with $n_1 = 2q$ and $n_2 = n - 3q$ degrees of freedom (see Andronov et al. 1992 for details).

The mean value of $S(f)$ for randomly distributed observations is $< S > = 2q/(n-q)$.

Moments of the Characteristic Events (PERMIN)

Andronov (1991, 1993) proposed the method and studied the statistical properties of test functions which are more complicated compared with that for normally distributed observations. The trial frequencies are chosen to be $f_i = i/(t_n - t_1)$ with corresponding least squares correction for all i. The program is computationally efficient because the frequency step is $\approx$ 10 times larger than that in the above mentioned cases.

A more complicated method was proposed by Dumont et al. (1978). Their method is compared with the least squares method in Andronov (1988).

Some dwarf nova stars show fast period changes from one value to another. These data were fitted by hyperbolic functions (Andronov and Shakun 1990). Similar changes occured in the semi–regular variable AF Cyg (Andronov and Chernyshova 1989).

Periodic Variations of O–C (FOUR–T)

This method may be applied for the moments of the characteristic events, but mathematically it is the same as the one–harmonic model with trend, so

$$\delta T_0 + E_k \delta P + C_3 \cos(\omega_E E_k) + +C_4 \sin(\omega_E E_k) = (O-C)_k \qquad (25)$$

Here $C_1 = \delta T_0$, $C_2 = \delta P$ are differential corrections to the initial epoch and period, respectively, and $(O-C)_k$ are deviations of the observed times from the ones "calculated" using a linear ephemeris $T_k = T_0 + PE_k$. The trial period $P_E = 2\pi/\omega_E$. The test function $S(f)$ for random data obeys the $B-$ distribution (10), but for n equal to the number of observations minus unity. After determination of the preliminary value of ω_E one may correct it by the method of differential corrections.

This program was applied to study various phenomena, e.g. the orientation changes of the white dwarf in the magnetic binaries AM Her (Andronov et al. 1982) and QQ Vul (Andronov and Fuhrmann 1987), the Blazhko effect in TT Cnc (Andronov et al. 1985), the presence of the third body in the eclipsing variable AK Her (Andronov et al. 1989).

"Smoothing the Smoothing Cubic Splines"

The method was proposed by Andronov (1987) and applied e.g. to the exotic binary V 361 Lyr (Andronov and Richter 1987) with a hot spot between the components, to a polar MR Ser (Andronov et al. 1992) and to a number of the Mira–type stars (Andronov et al. 1988ac, 1992a).

Autocorrelation Function Analysis of the Detrended Data of Finite Length

Influence of the finite length of the data run and subtraction of the least squares fit in general form was discussed by Andronov (1994). If the unbiased ACF is ρ_u, the biased one is r_u, one may write the mathematical expectation

$$r_u = R_u/R_0,$$

$$R_u = \sum_{i=0}^{n-1} Z_{iu}\rho_i. \qquad (26)$$

The matrix Z_{iu} is a degenerate, thus one may not restore the unbiased ACF from observations. The only way involves the modeling of ρ_i and the determination of the model parameters by fitting the observed ACF with a computed one r_u. Thus the restored ACF is model–dependent.

One may note that the $n \times n$ matrix Z_{iu} depends on the basic functions used to determine the removed trend and on the run length n. Computational time for $n = 256$ and cubic polynomial is $\approx$ 60 hours using a 33 MHz PC–486. Such a matrix is to be computed for a desired regime and then stored as a file for further data fits.

Although the ACF may be used to study periodic signals, it is much more useful to determine parameters of the autoregressive processes which allows estimates of the contribution of the uncorrelated noise.

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PERIOD ANALYSIS OF THE RR LYRAE STAR AE BOOTIS

V. P. Bezdenezhnyi
Astronomical Observatory, Odessa State University,
T.G.Shevchenko Park, Odessa 270014 Ukraine

ABSTRACT. The Fourier analysis performed for photoelectric Penston's (1972) observations of the RR_c Lyrae variable AE Boo shows that the star may be multiperiodic with most significant frequencies f_{1H}, f_F, f_{2H}, $3/2f_F$, $5/4f_F$ and their linear combinations.

Key words: Stars: RR Lyrae type, Fourier analysis

By using Breger's (1991) program PERIOD the Fourier analysis was carried out of photoelectric V-magnitudes for the c-type RR Lyrae star AE Boo obtained by Penston (1972) within 3 years (J.D. 2439971 - 2441065) which gave the following elements consistent with observations:

$$Max_{hel} = J.D.2440771.810 + 0.314897\,E \quad (1)$$

With the light variation amplitude of 0.44 mag the mean light curve shows a scatter of 0.1 mag. The following idea suggests itself: the star may be multiperiodic.

The Fourier analysis has given the most significant value of the fundamental period P_{1H}=0.3148956^d (f_{1H}=3.1756547). After subtracting it the Fourier analysis of residuals has displayed several dominating frequencies. The reduction of residuals with each of the corresponding periods to the mean curve failed to yield the result expected: the mean curves showed nearly the same scatter as the curve with respect to the fundamental period. Therefore, fits with frequencies multiple with the fundamental (f_{1H} and its harmonics) were performed to observations in order to take into account the light curve asymmetry. This fit was subtracted from observations and for residuals the Fourier analysis was done. In the power spectrum significant frequencies can be seen. They had larger amplitudes or comparable with those of subtracted harmonics. Therefore, harmonics of frequency f_{1H} higher then the third were substituted by the most significant constituents with frequencies: $f_F=3/4f_{1H}$, $f_{2H}=5/3f_F$, $f_{3H}=2f_F=3/2f_{1H}$ and f_{4H}.

With the value of P_F=0.420^d for AE Boo Petersen's (1990) models with enhanced metal opacity provide a very good agreement of period ratios for first four overtones to P_F (for P_{4H} somewhat worse) with our determinations and multiplicity ratios: P_{1H}/P_F=0.748, P_{2H}/P_F=0.596, P_{3H}/P_F=0.500, P_{4H}/P_F=0.428.

Standard models constructed for Population I pulsators are less suitable in this case: P_{1H}/P_F=0.765, P_{2H}/P_F=0.610, P_{3H}/P_F=0.509, P_{4H}/P_F=0.435.

In Table 1 are represented results of the fit giving minimum residuals: frequencies, amplitudes, phases, f_F/f_i ratios and theoretical ones close to them from multiplicity viewpoint, as well as identifications. Besides the above frequencies there are also linear combinations of f_{1H} and f_F according to the formula:

$$f_{ij} = i f_{1H} + j f_F, \quad (2)$$

used by Jerzykiewicz et al. (1982) when analyzing the light curve of AQ Leo.

However, there are two more frequencies introduced by us: $f_E = 5/4f_F$ and $f_G=3/2f_F$, and their combinations: $f_{4H}=f_F + f_E$, $2f_E=f_F + f_G$, $3f_E=f_{4H} + f_G$. In the case of AE Boo observations are also represented as a synthetic light curve being a sum of sinusoids:

$$m(t) = \bar{m} + \Sigma_i A_i \sin[2\pi f_i(t - t_0) + \varphi_i], \quad (3)$$

its main terms are given in Table 1.

In addition to harmonics of fundamental and first overtones in AQ Leo described by Jerzykiewicz et al. (1982) and discovered by Fitch

Table 1. Results of fits with minimum residuals.

$freq_i$	Amp_i	φ_i	f_F/f_i	$(f_F/f_i)_{theor}$	P_i	ident.
2.3795079	0.025	0.242	1	1	0.42025496	f_F
2.9787811	0.012	0.728	0.799	0.800	0.3357077	$f_E=5/4f_F$
3.1756544	0.214	0.561	0.749	0.750	0.31489572	$f_{1H}=4/3f_F$
3.5735541	0.015	0.494	0.666	0.667	0.2798334	$f_G=3/2f_F$
3.9698965	0.014	0.951	0.599	0.600	0.25189573	$f_{2H}=5/3f_F$
4.7603339	0.013	0.282	0.500	0.500	0.21006929	$f_{3H}=2f_F$
5.3698130	0.016	0.538	0.443	0.444	0.18622622	$f_{4H}=f_F+f_E$
5.9484201	0.017	0.560	0.400	0.400	0.1681118	$2f_E$
6.3524091	0.018	0.592	0.375	0.375	0.15742059	$2f_{1H}$
7.1400110	0.009	0.149	0.333	0.333	0.1400558	$2f_G$
4.4644466	0.015	0.621	0.533	0.533	0.2239919	$3/2f_E$
8.9304208	0.014	0.582	0.266	0.267	0.1119768	$3f_E=f_{4H}+f_G$
7.9403691	0.017	0.834	0.300	0.300	0.1259387	$2f_{2H}=f_{1H}+f_{3H}$
9.5303409	0.013	0.233	0.250	0.250	0.10492804	$3f_{1H}$

and Szeidl (1976) fundamental, first and second overtones in AC And, in the light curve of AE Boo there arise frequencies f_E and f_G too as well as their linear combinations.

To formula (3) are subjected also observations of the c-type RR Lyrae star ST CVn with its three basic frequencies found by Penicke et al. (1989), 0.755, 3.0395, 6.1950 c/d, which we identify with $f_{1H}/4$, f_{1H} and $2f_{1H}$, respectively. As in the case AE Boo, the frequency f_{1H} is dominating here which is characteristic of c-type RR Lyrae pulsators. At such an identification the ratios of periods: $P_{1H}/4P_{1H}=0.249$ and $(P_{1H}/2)/P_{1H}=0.491$ are close to theoretical ones from the multiplicity viewpoint. And there is no necessity of resorting to the hypothesis of a nonradial pulsator. Thus, formula (3) reflects the essence of multimodal light variations of stars.

Observational range of AE Boo being represented within 3 years with 15 nights only, a further large set of observations would be needed in order to confirm results obtained.

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ON PERIODS OF OSCILLATIONS IN δ SCUTI TYPE STARS

V. P. Bezdenezhnyi
Astronomical Observatory, Odessa State University,
T.G.Shevchenko Park, Odessa 270014 Ukraine

ABSTRACT. In considering both commensurability spectra of oscillation frequencies for δ Sct stars and the distribution of periods for these variables from Kotov's (1987) data, frequencies f_F, f_{1H}, f_{2H}, $5/4 f_F$ and $3/2 f_F$ are found, as well as their linear combinations. For 13 stars with two known periods identifications are carried out.

Key words: Stars: δ Sct, RR Lyrae, mode identifications

In the work by Kotov (1987) in analyzing commensurability spectra of oscillation frequencies for δ Sct stars a statistically significant tendency has been found for stars' number excess with frequencies multiple to that of f_0 or with frequencies for which f_0 is multiple to:

$$f_i \approx \begin{cases} z f_0, & \text{if} \quad f_i \geq f_0, \\ f_0/z, & \text{if} \quad f_i < f_0, \end{cases} \qquad (1)$$

where z=1,2,3, and the period f_0^{-1} = 162.2 min ± 2.8 min within the limits of error is in good agreement with the value by Stellingwerf (1979), 161 min, for a typical δ Sct Star, and with a famous period of global pulsations of the Sun (see Kotov (1987) and references therein).

In the commensurability spectrum, the second in significance peak (P_2=96 min = 0.0663 days) is seen. Kotov (1987) considers it to be "artifact" associated with the maximum in distributing periods of δ Sct stars in this range. However, we assume this peak to be real (Fig.1), and hence the period corresponding to it as well. The ratio of $P_2/P_0 = 0.592$ is very close to 3/5 which is characteristic of the second overtone of pulsations. Hence, P_2 is P_{2H}. In addition to these statistically significant two peaks, three less powerful peaks are seen: 77, 44 and 236 MHz (see Table 1). Their identifications are likely to be: $3/4 f_0$, $f_{2H}/4$ and f_{4H} (last - from observed period ratio P_{4H}/P_0=0.436 close to the theoretical value 0.437 obtained by us according to Petersen's data (1990) for standard models of multimodal Population I pulsators).

With Fourier analysis of periods of RR_c star AE Boo performed (see in the same volume) two frequencies $f_E = 5/4 f_F$ and $f_G = 3/2 f_F$ were introduced which were found in the power spectrum as well as their linear combinations with f_F and f_{1H}. As is seen these are present in δ Sct type stars too: $f_{4H} \approx f_0 + f_E$ and $3/4 f_0 \approx f_G/2$.

Peaks in distributing periods can be noticed from Figure 1: $P_{2H}/3$=0.022, $P_0/3$=0.038, P_{4H}=0.049, $P_0/2$=P_{3H}=0.056, P_{2H}=0.066, P_G=0.075, P_{1H}=0.084, P_E=0.090, P_0=0.1126, $2P_{2H}$=0.135, $3P_{4H}$=0.148, $2P_G$=$4/3P_0$=0.151, $3P_{3H}$=0.169, $2P_E$=$8/5P_0$=0.180, $4P_{4H}$=0.197, $3P_{2H}$=0.199, $2P_0$=$3P_G$=0.225, $3P_{1H}$=0.253, $4P_{2H}$=0.265, $3P_E$=0.270 days and others.

Thus, the histogram of period distribution supports the data given in Table 1: frequencies f_0, f_{2H}, f_{4H}, f_E and f_G are related with multiplicity ratios. In the commensurability spectra (Kotov, 1987) the frequencies f_{1H}, f_E and f_G, besides the above, are noticed too in the wings of two basic peaks as humps.

In Table 2 are represented data for two periods of 13 particular stars of δ Sct type from the Kotov's list (1987) and their probable identifications. In 10 cases of 13 the period ratios observed are different from those of their multiplicity within 0.02, in two stars the difference being equal to 0.03 and in LT Vul to 0.05. Taking into account some possible errors to appear when determining the periods, as well as the diversities of masses and chemical compositions in the stars, the fit would seem to be

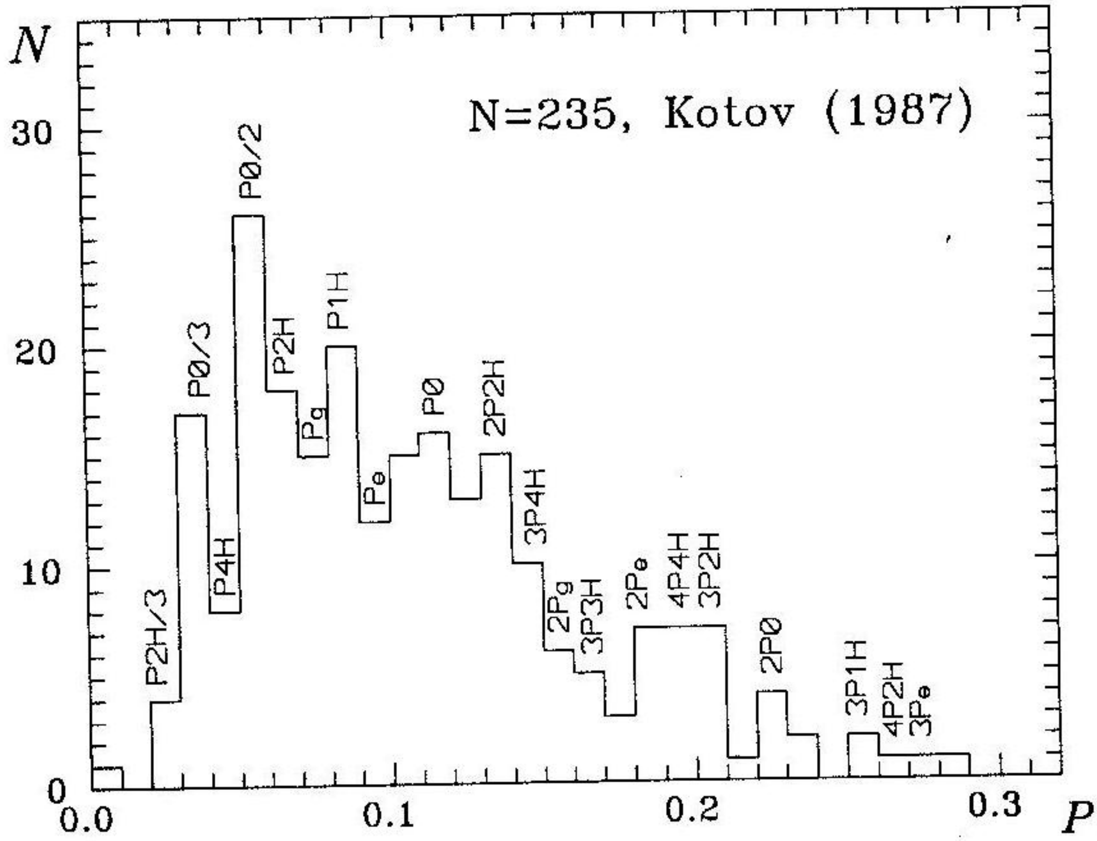

Figure 1. The distribution of oscillation periods from data of sampling according to Kotov (1987).

Table 1.

f_i(MHz)	f_i(1/days)	P_i(days)	P_i(min)	k_i=P_i/P_0	identifications
103	8.881	0.1126	162	1	f_F
175	15.079	0.0663	96	0.592	f_{2H}
77	6.637	0.1507	217	1.338	$3/4f_F=f_G/2$
44	3.793	0.2637	380	2.341	$f_{2H}/4$
236	20.342	0.0492	71	0.436	$f_{4H}=f_F=F_E$

Table 2.

star	P_1	P_2	k=P_2/P_1	k_{theor}	Δk	identifications
EM Aqr	0.095	0.068	0.72	0.75	0.03	P_E and P_{2H}
UV Ari	0.06	0.037	0.62	0.60	0.02	$P_F/2$ and $P_{2H}/2$
VV Ari	0.76	0.063	0.83	0.83	0.00	P_{2H} and P_{3H}
AI CVn	0.209	0.139	0.67	0.67	0.00	$2P_F$ and $2P_G$
AO CVn	0.135	0.1218	0.90	0.90	0.00	$2P_G$ and $2P_{2H}$
UU Com	0.028	0.021	0.75	0.75	0.00	$P_F/4$ and $P_{1H}/4$
S Eri	0.1558	0.1188	0.76	0.75	0.01	$2P_G$ and P_F
HQ Hya	0.097	0.076	0.78	0.80	0.02	P_F and P_E
V465 Per	0.070	0.030	0.43	0.44	0.01	P_{2H} and $P_E/3$
VY Psc	0.219	0.163	0.74	0.75	0.01	$2P_F$ and $2P_{1H}$
IM Tau	0.1449	0.1120	0.77	0.75	0.02	$2P_G$ and P_F
LT Vul	0.1096	0.0935	0.85	0.80	0.05	P_F and P_E
10 NGC6871	0.1082	0.0903	0.83	0.80	0.03	P_F and P_E

fairly well.

Similarly to multimodal RR Lyrae type stars, the periods of δ Sct stars are close to those of P_F, P_E, P_{1H}, P_G, P_{2H} and their combinations.

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SEARCH FOR LONG-TERM VARIATIONS OF dKe-dMe STARS

N. I. Bondar'
Crimean Astrophysical Observatory, Nauchny 334413 Crimea, Ukraine
E-mail: bondar@crao.crimea.ua

ABSTRACT. Measurements of brightness of 29 red dwarf stars and 3 stars of other types were made on time scales of 5 – 90 years using plates archives of Sternberg State Astronomical Institute (Moscow), Astronomical Observatory of Odessa State University and Sonneberg Observatory (Germany). The sensitivity of plates are close to B band. The long- term changes in yearly mean magnitude have been detected or suspected for 10 dKe–dMe objects. Two stars, V833 Tau and PZ Mon, show high amplitude of variability up to 0.6 – 1.0 mag. The range of variability in mean light of the other eight stars is of 0.2 – 0.5 mag. The light curves show typical times of long–term variability of about 30–60 years. Changes of the mean light of the remained dKe–dMe stars and three other stars of other types – FK Com, V654 Her, AE Aqr – do not exceed 0.2 mag. Complete paper is to be published in: *Izvestija Krymskoy Astrofizicheskoy Observatorii*, v.**91**.

Key words: Stars: Variable

RESULTS OF LONG-TERM OBSERVATIONS OF EARLY-TYPE STARS WITH CIRCUMSTELLAR SHELLS

Yu. K. Bergner[1], A. S. Miroshnichenko[1], R. V. Yudin[1], D. B. Mukanov[2]
[1] Central Astronomical Observatory, Pulkovo, Saint-Petersburg 196140 Russia,
E-mail: anat@gaoran.spb.su
[2] Astrophysical Institute of the National Academy of Sciences of Kazakhstan,
Almaty 480068 Kazakhstan,
E-mail: adm@afi.academ.alma-ata.su

ABSTRACT. The results of UBVRIJHK photometric, RI polarimetric, and spectral observations of three Herbig Be stars MWC 137, MWC 297, and MWC 1080 are presented. Brightness variability and spectral features are analyzed. Evidences of cool star presence in MWC 297 are reported. Characteristics of central stars and their shells are estimated.

Key words: Stars: emission-line, circumstellar matter, photometric variability, binaries.

Determination of physical characteristics of stars with gas and dust shells is an important and difficult problem of modern astrophysics. This paper is devoted to the complex study of Herbig Be stars MWC 137, MWC 297, and MWC 1080 still having an uncertain status. All the objects have bright hydrogen and Fe II emissions in their spectra. Brightness variability has been studied only for MWC 1080 (Grankin et al., 1992). Photometric UBVRIJHK observations were made with the 1-m telescope of the Astrophysical Institute (Assy) using the photometer-polarimeter FP3U (Bergner et al. 1988) between 1984 and 1992. It was obtained about 30 observations of MWC 137 and about 50 of MWC 297 and MWC 1080. One of the authors (A.M.) obtained several spectra of each star in 1989–1991 in the range of 4000–7000 Å using the scanner of the 6-m telescope of RAS. The dispersion was 50 and 100 Å/mm. We have detected some absorption features typical for late-type stars in the spectrum of MWC 297 and that of early-type in MWC 137. There were no evidences of absorptions in the spectrum of MWC 1080. Photometric observations have shown that all the objects have brightness variability. Its amplitude for MWC 137 is about 0.4 mag. in the optics and about 0.6 in the near-IR. We have also detected the quasi-period of 4.07 days.

The mean polarization in the R-band was about 6%. The mean brightness level of MWC 297 was decreased by 0.4 mag. between 1984 and 1989. Detailed analysis of its variability shows some maxima and minima with possible quasi-period of nearly 25 d. Brightness of MWC 1080 changed between V = 11.2 and 11.8 mag without evidences of periodicity.

Its polarization increased between 1985 and 1992 from 1.5–2 to 2.5–3.5%. We suppose that MWC 297 may be a binary system with early-B and early-K components surrounded by a strong gas and dust shell. This model can explain its high reddening together with the Balmer decrement and SED in the wide spectral range. MWC 137 seems to be a young early-B star with an accretion disk (which explains a high radio flux from the object and the radio spectrum). MWC 1080 is probably an early-B supergiant just after the stage of Main Sequence.

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NEW VARIABLE STAR IN THE ORION CONSTELLATION

I. S. Brjukhanov[1], V. P. Goranskij[2]
[1] Amateur Group of Variable Stars Observers, Minsk, Belaruss
[2] Sternberg State Astronomical Institute
Universitetskij Prospect 13, Moscow 119899 Russia

ABSTRACT. New variable star with $\alpha = 05^h57^m22^s$, $\delta = +20°15.5'$ (1950) was discovered with elements JD Max=2436999.28 + 0.2343973·E, range $15.6-16.2^m$ (pg) and asymmetry M–m=0.26.

Key words: Stars: Pulsating

Variability of the star in Orion was discovered by I.S.B. when measuring 43 negatives of the 40-cm Crimean astrograph with a blink-comparator of the Sternberg State Institute. Co-ordinates were determined by linking to that of reference stars published by H.Vehrenberg (*Atlas Stellarum*). The brightness of the comparison stars was determined: c (0.0^{st}, 15.54^m), d (14.5^{st}, 15.83^m), e (26.0^{st}, 16.08^m).

Period search from 0.1^d to 5000^d by V.P.G. has shown that the star is variable with parameters listed in the Abstract, and may belong to a SX Phe subtype (or RRc or δ Sct). Finding chart is shown at Fig.1, the phase light curve - at Fig. 2. Analysis of the *Palomar Atlas* images shows that the star is white or yellow. The outstanding points at Fig. 2 were checked and justified. Possibly the significant Blazhko effect is present.

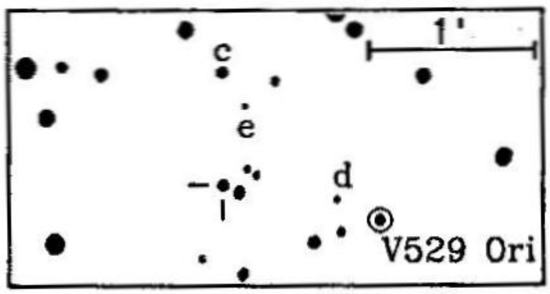

Figure 1: Finding chart for the new variable.

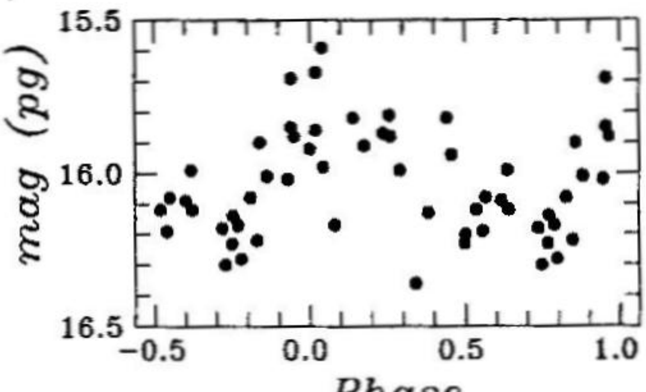

Figure 2: Phase light curve corresponding to $P = 0.2343973^d$

THE INVESTIGATION OF CEPHEIDS RT AUR, T VUL, κ PAV BY A TWO-COMPONENT "CURVE-OF-GROWTH" METHOD

Z. N. Fenina, N. S. Zgonyaiko, S. V. Vasilyeva
Astronomical Observatory, Odessa State University,
T.G.Shevchenko Park, Odessa 270014 Ukraine
E-mail: root@astro.odessa.ua

ABSTRACT. For 3 cepheids (RT Aur, T Vul, κ Pav) the physical and chemical parameters are obtained: spectral class, electron pressure, "microturbulent velocity", relative number of atoms in different chemical elements. The variations of this parameters with a phase are investigated.

Key Words: Stars: Cepheids: Individual: RT Aur, T Vul, κ Pav

The determinations of the spectrum forming layer temperature by different methods (from photometric data, hydrogen line profile, the level of a continuous spectrum, ionization temperature) fail to give consistent results. Because of this, it is practically impossible to construct a "curve-of-growth" by a classical method using one of these temperatures, even with a rather reliable system of oscillators strengths present. The analysis of numerous spectra of pulsating stars by a qualitative spectral classification method has shown that it is necessary to consider at least three levels of forming absorption lines present in every quasistationary state in the pulsating atmosphere: hydrogen, ionized calcium and other metals. Incidentally, each level has its own temperature called local one which in separate phases can coincide on all the levels or strongly differ among themselves. The empirical method of local kinetic temperature determination on levels of forming heavy element absorption lines is based on investigation by using a method of successive approximations of dependence of Fe I equivalent width intensities on excitation temperature in cepheids RT Aur, T Vul, κ Pav. (Fenina et al., 1990, 1991). The investigation of the three cepheids by a two-component "curve-of-growth" method (Fenina et al., 1988, 1990) has resulted in deriving a number of physical – chemical parameters and their phase variations: temperature, spectral type, electron pressure, turbulent velocity, relative number of atoms in different chemical elements. Phase variations in spectral characteristics in every cepheid show their own peculiarities which have not been displayed at all in investigation by the "curve-of-growth" method relative to the Sun and by the scanning method of UBV photometry. It is common for all the above cepheids to have two temperature levels which without mixing pass the stage of maximum light. To objectively estimate some physical parameters (relative number of atoms, electron pressure and turbulent velocity), a standard has been created on the basis of investigating stationary stars close in spectral type to RR Lyrae stars and cepheids. As an initial material equivalent widths for 10 stars have been used which were obtained by different authors from spectrograms with close dispersion 10 Å/mm.

Taking into account that each of stationary stars can show individual peculiarities their analysis has been done by a two-component "curve-of-growth".

Standardization of chemical composition

The question of chemical composition of atmospheres of RR Lyrae type stars and cepheids is of a principal importance as upon it depend conclusions drawn on chemical composition of stellar clusters and eventually on stellar evolu-

Table 1: Relative number of atoms of chemical elements

element	lg(*N*/*H*)	σ	*n*	Sun	element	lg(*N*/*H*)	σ	*n*	Sun
Al	5.24	0.96	6	6.49	Ni	4.67	0.42	3	0.22
Si	6.38	1.38	5	7.64	Sr	0.95	0.34	7	2.90
Ca	5.54	0.64	6	6.38	Y	1.48	0.56	7	2.24
Sc	2.01	0.58	14	3.06	Zr	1.71	0.66	10	2.56
Ti	4.12	0.35	15	5.06	Ba	1.14	0.79	4	2.11
V	3.47	0.47	12	4.00	La	1.22	1.08	6	1.10
Cr	4.69	0.64	14	5.64	Ce	0.49	0.32	4	1.60
Mn	5.37	1.10	7	5.40	Nd	0.63	0.39	3	1.40
Fe	6.60	0.39	13	7.64	Eu	0.23	0.18	3	0.50
Co	3.95	0.06	3	4.92					

tion trends. Chemical composition is adopted to imply a relative number of atoms in different elements per 10^{12} hydrogen atoms.

In Table 1 are shown average values of the parameter of a relative number of different atoms lg(N/H), their mean quadratic deviations and a number of estimations n. For comparison, solar data from the work by Gurtovenko and others are given (1989). Within 3σ the relative number of atoms in different elements agrees with the solar one. One can suggest that it is a natural dispersion inherent to different stationary stars. In case a deviation in the relative number of some elements in the atmosphere of a pulsating star exceeds natural dispersion, it is suggestive of their deficiency or excess on the whole or in separate phases. The investigation of a diagram of $\lg(N/Fe)_{*} - \lg(N/Fe)_{st}$ from different chemical elements in stars of the standard and cepheids RT Aur, T Vul, κ Pav has shown that in cepheids the dispersion is much larger than in stationary stars, incidentally it changes depending on the phase of light variation.

Standardization of electron pressure

From lines of neutral and ionized iron, electron pressure $\lg P_e$ for stars of the standard and cepheids T Vul, RT Aur, κ Pav has been determined. As a result, the dependence of $\lg P_e$ on θ_{ex} is shown to be linear and for stationary stars approximated by equation:

$$\lg P_e = -9.118\theta_{ex} + 7.775$$

For cepheids approximated by equation:

RT Aur	$\lg P_e = -5.600\theta_{ex} + 4.705$
T Vul	$\lg P_e = -8.125\theta_{ex} + 7.536$
κ Pav	$\lg P_e = -2.747\theta_{ex} + 1.365$

Linearity of $\lg P_e$ dependence on θ_{ex} testifies to the existence of ionization equilibrium in the atmospheres of cepheids, in each phase the state may be accepted as being quasistationary.

Standardization of "microturbulent velocity"

The term of "microturbulent velocity" is defined in the given case as a difference in the $\lg W_\lambda/\lambda$ scale which arises between a theoretical and an experimental "curves-of-growth" and has a dimension of km/sec. These data are burdened with errors related to an instrumental contour of spectral lines (depth) and to the equivalent widths rise as the effective temperature drops (Megin, 1984). In order to empirically take into account the temperature influence on V_t km/sec a dependence of "microturbulent velocity" for stationary stars on Sp(M) – spectral type, as measured from Fe I lines, i.e. on temperature has been constructed. The derived dependence is of linear character, at least within B5 – G0 range and approximated by the equation of the form: $V_t = 7.147\theta_{ex} - 2.617$ The derived mean dependence is used for estimation of proper "microturbulent velocities" of three cepheids κ Pav, T Vul, RT Aur. The scattering of proper "microturbulent velocities" for cepheids was proved to be in order of ± 2 km/sec.

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RAPID PHOTOMETRY OF THE HD 197406 (WN7): SEARCHING FOR FLARE ACTIVITY IN WOLF–RAYET STARS

V. R. Khalack, B. E. Zhilyaev
Main Astronomical Observatory
Golosiiv 252127, Kyiv–127 (Kiev), Ukraine
E-mail: shulman@gao.kiev.ua

ABSTRACT. We have undertake a study of Wolf–Rayet star HD 197406 in order to test an existence of stable periodic changes of light curve, which can arise as result of interaction of rotating compact companion and fast, dense, hot stellar wind. The observations of this star have been carried out in August and October 1991, and in August 1993 at the high–altitude Observatory Peak Terskol (3100m) North Caucasus with the help of 60cm telescope and high–speed double–channel photometer. The HD 197406 was monitored in UBV and moderate–band filters, that cover the range of pure continuum (central wavelength 4270Å and FWHM 100Å) and the range of He II 4859Å line (central wavelength 4870Å and FWHM 140Å). Star BD +52°2783 (Sp B9) was used as a reference star. Monitoring of two stars, HD 197406 and BD +52°2783, was carried out simultaneously in two parallel channels at the same filters with the integrating times from 0.05 sec to 1.0 sec continuously during from 10 min to 1.5 hour. Besides, we observed the Wolf–Rayet star simultaneously in two channels in different filters. The obtained data reveal a flare variability at the pure continuum during about 1.5 min. In this case, the flares last about 1.0 sec and reach 0.2–0.3 magnitude. Variability of light curve in U,B and range of He II 4859 Å line also is detected. On the other hand, the stable periodic changes of light curve isn't detected with confidence. Therefore, such variability seems to arise rather as a result of magnetic field action on the surface of star, than as result of interaction of rotating compact companion with stellar wind. New observations of HD 197406 are needed, especially at the range of strong He II 4686 Å line, in order to clarify the physical situation.

Key words: Stars: HD 197406 – star: Wolf–Rayet – stars: flare – stars: photometric.

LINEAR POLARIZATION OF RY TAURI AFTER ITS "FLASH" IN 1983 OCTOBER

V. I. Kardopolov, F. K. Rspaev
Fesenkov Astrophysical Institute, 480068 Almaty, Kazakhstan

ABSTRACT. Simultaneous photoelectric and polarimetric BVR measurements of RY Tau have been obtained from 1987 December to 1993 March. A "flash" changed usual behavior of the star, possibly indicating the binarity of the system.

Key words: Stars: pre–main–sequence – Stars: photometry and polarimetry – Stars: RY Tau – Stars: Binaries

At the end of 1983 – in the beginning of 1984 the extraordinary increase of the InT variable star light flux (for 0.5 magnitude in V band) occurred and the character of the stellar brightness behaviour changed (Herbst & Stine 1984; Zaitseva et al. 1985; Kardopolov & Rspaev 1990). There were no any regularities in the star color/magnitude diagrams in the preceding years. However, near the new photometric maximum after the RY Tau "flash" the direct correlation between reddening degree and a light variability of the star takes place. Up to date this kind of the InT variable star brightness behaviour is still the same.

Our measurements indicate that the light flux increase has influenced to the other parameters of RY Tau continuum radiation. Before 1983 October, for instance, a dependence of the star linear polarization degree on its photometric variability was absent. But after the "flash" the contribution of the polarized light rises with the increase of the light flux (in the RY Tau bright state). The positional angle as always did not correlate either with the brightness or with the polarization values of RY Tau.

At the same time episodic light weakenings of the star to the brightness before its "flash" are observed. Simultaneously the relation of polarization degree to photometric variability vanishes, i.e. the parameter P arbitrarily changes again. Thus RY Tau returns temporarily to the state like before 1983 October one.

All the enumerated features of RY Tau activity should be understood, if, for example, two objects, unresolved for an observer, were located toward it. One of them was not registered on the brighter companion background before 1983 October. The star "flash" has done it visible. Its properties observed about a new RY Tau light maximum only. When the companion weakens, we observe the well-known InT variable star. It is a possible close binary system (Herbig 1977; Nurmanova 1982).

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INFLUENCE OF SHOCK WAVES ON THE LIGHT CURVES OF LONG-PERIOD VARIABLES

L. S. Kudashkina[1], G. M. Rudnitskij[2]
[1] Astronomical Observatory, Odessa State University
T.G.Shevchenko Park, Odessa 270014, Ukraine
e-mail: root@astro.odessa.ua
[2] Sternberg Astronomical Institute, Moscow State University
13 Universitetskij prospekt, Moscow 119899 Russia
e-mail: gmr@sai.msu.su

ABSTRACT. The shapes of light curves of Mira-type variable stars is analyzed. It is shown that some features of the light curves may be explained by passage of shock waves in the stars' atmospheres. In particular, it is noted that "steps" of the ascending branches of the light curves have very similar durations (of the order of 0.1 stellar period) for a big number of miras. This time span is just approximately the time of propagation of shock waves through stars' atmospheres. The numerical simulation of shock wave propagation support the above suggestion and yield time scales that fit the observed light curve features.

Key words: Stars: Miras, light curves, stellar atmospheres, shock waves.

For long–period variables, the shape of light curves is determined to a considerable extent by influence of shock waves, which propagate in the star's atmosphere and in the inner layers of the circumstellar envelope during each cycle of the stellar variability. Of interest are also some peculiarities of the light curves: "humps", "steps" on the ascending branch and – as an extreme case – double maxima. It can be said that the "normal", stable state of a long–period variable is the minimum light, whereas the shock waves, caused by stellar pulsations, move the star from this state to the "excited" state, which is connected with the light maximum. The increase of brightness in the visible and infrared is in the first turn due to an increase of temperature of the photospheric layers that are responsible for the stellar continuum in the visual.

In order to investigate the influence of shock waves on the light curves, we constructed a numerical model of propagation of a shock in mira's atmosphere. We accounted for the effects of ionization of gas and for dissociation of molecular hydrogen on the shock front. We assumed the shock to be spherical. The initial radius was $\sim 3 \cdot 10^{13}$ cm. Then, with a fixed step in time (10^5–10^6 s), we computed the gas physical parameters for the current shock radius. According to Willson (1976), we assumed that the shock velocity falls with growing radius as $D = D_0(r_0/r)^\alpha$; from empirical data, $\alpha = 1$. Here D is the current shock velocity, D_0 – its initial value at $r = r_0$. We varied D_0 between 20 and 100 km s^{-1}. We assumed also the postshock ionization and dissociation to be determined by Saha–type equations.

We solved by the iteration method the system of equations for the quantities

$$z = \frac{p_2}{p_1} = \frac{2\gamma_1 \mathrm{M}^2}{\gamma_2+1}\left[1+\frac{(\gamma_2^2-1)\,q}{2D^2}\right],$$

$$\frac{T_2}{T_1} = \frac{2\gamma_1(\gamma_2-1)\,\mu_2 \mathrm{M}^2}{(\gamma_2+1)^2\,\mu_1}\times \left[1-\frac{(3-\gamma_2)(\gamma_2+1)\,q}{2D^2}\right], \quad (1)$$

where q is the energy spent for ionization and dissociation, M is the Mach number, γ – the adiabatic index, μ – the molecular we-

Table 1: Characteristics of individual stars. Notes: Gr. – group of periods (I – $P < 200^d$; II – $200^d < P < 300^d$; III – $300^d < P < 400^d$; IV – $P > 400^d$); f – asymmetry of the light curve; T – duration of the hump; ′ – the period was redetermined.

Star	P, days	Gr.	Sp. (latest)	f	lg (T/P)	T/P	lg$[\Delta P/P]$
R Hor	407.6	IV	M8eII-III	0.40	−0.844	0.1431	
U Aur	408.09	IV	M9e	0.39	−0.845	0.1429	
S Scl	362.57	III	M9e (Tc)	0.48	−1.002	0.0996	
V Cyg	421.27	IV	C7.4e	0.46	−1.005	0.0989	
S Cep	502.34	IV	C7.4e	0.55	−0.864	0.1369	−1.498′
T Cep	388.14	III	M8.8e	0.54	−0.915	0.1217	
R Cas	443.88	IV	M10e	0.40	−1.111	0.0774	−1.506′
W Peg	345.5	III	M8e	0.46	−0.919	0.1206	
RU Tau	544.6	IV	M6.5	0.62	−0.845	0.1428	
V Cam	503.16	IV	M7e	0.31	−0.973	0.1063	−1.433
χ Cyg	421.54	IV	S10.4e(MS)	0.41	−1.167	0.0681	
R Aur	448.10	IV	M9.5e	0.51	−0.874	0.1336	−1.686
Y Cep	322.57	III	M8.2e	0.40	−1.124	0.0752	
W And	399.24	III	M10(S9.2e)	0.42	−0.923	0.1193	−2.076′
o Cet	333.47	III	M9e	0.38	−1.036	0.0921	−2.347′
RR Cep	384.18	III	M8.8e	0.41	−0.862	0.1374	
RT Oph	426.34	IV	M7e(C)	0.36	−1.107	0.0782	
U Her	415.69	IV	M9.5e	0.40	−1.019	0.0958	−1.627′
NP Her	448	IV	C6.3e	0.5	−1.003	0.0992	
RU Her	484.83	IV	M9	0.43	−0.941	0.1146	
U Ser	237.50	II	M6e	0.48	−0.591	0.2563	
W Cas	417.98	IV	C7.1e	0.46	−0.891	0.1286	−1.444′
T Phe	281.79	II	M5e	0.37	−0.973	0.1065	
R Cam	270.22	II	S8.7e	0.45	−0.727	0.1876	
RS Her	219.70	II	M8:	0.47	−0.919	0.1206	
VZ Cas	169.24	I	M3e	0.46	−0.985	0.1034	
RS UMa	258.97	II	M6e	0.42	−1.178	0.0664	
R Vir	145.95	I	M8.5e(III)	0.50	−1.204	0.0625	−2.678′
TU And	318.36	III	M5e	0.48	−1.140	0.0725	−2.301′
R Leo	313.67	III	M9.5eIII	0.43	−1.307	0.0493	−1.921′
U CMi	422.03	IV	M4e	0.52	−0.768	0.1707	−1.706′
X Cas	441.94	IV	C5.4e	0.55	−0.658	0.2200	−1.345′
T Cas	465.35	IV	M9.0e	0.56	−0.894	0.1275	−1.336′
R UMa	301.53	III	M9e	0.39	−1.342	0.0455	−3.523′
T Cam	374.80	III	S8.5e	0.47	−1.135	0.0732	−2.367′
T UMi	316.74	III	M6e	0.45	−1.313	0.0486	−1.281′
S Umi	225.87	II	S5.9e	0.47		0.2117	
R Aqr	386.96	III	M8.5e	0.42		0.1236	
X UMa	249.04	II	M4e	0.43		0.0524	
S Leo	190.16	I	M6e:	0.47		0.1829	
T Lyn	406.0	IV	C7.1e(N0e)	0.47		0.1071	
U Lyn	433.6	IV	M9.5:e	0.42		0.1604	
SZ Aur	454.04	IV	M8e	0.46		0.2394	

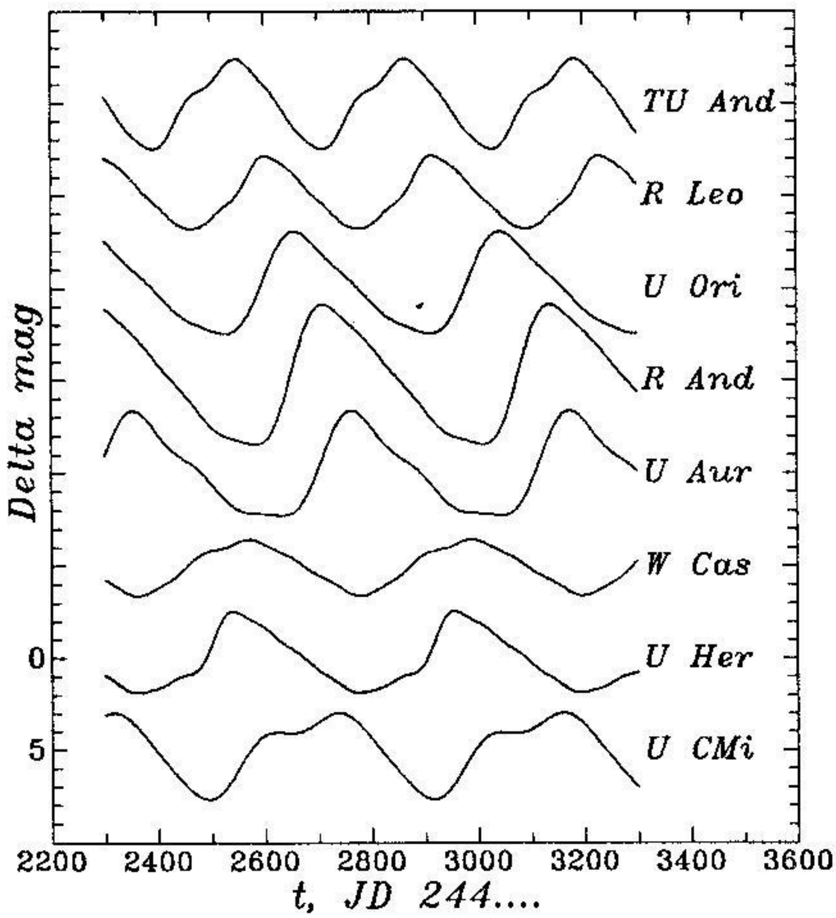

Figure 1: The smoothed light curves of some Mira–type stars with periods $300^d < P < 400^d$. The observations were obtained by the AAVSO members (Mattei et al. 1978). For approximation we have used a program FOUR-N by Andronov (1994) which determines a least squares fit with different number of harmonics.

Table 1 (continued)

Star	P, days	Gr.	Sp. (latest)	f	lg (T/P)	T/P	lg$[\Delta P/P]$
V Del	533.51	IV	M6e	0.42		0.0978	
U Ari	371.13	III	M9.5e	0.40		0.1172	
S CMi	332.94	III	M8e	0.49		0.1045	
R CVn	328.53	III	M9e	0.46		0.1191	
R LMi	372.19	III	M9.0e(Tc:)	0.41		0.0935	

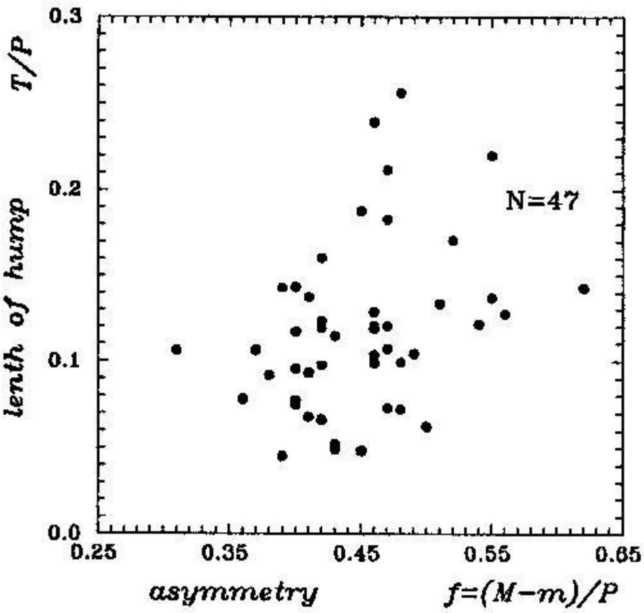

Figure 2: The relationship "duration of the hump - asymmetry". NP Her is not included.

ight. Subscripts 1 and 2 refer to the pre– and postshock gas parameters respectively. Detailed expressions for the quantities, entering the above formulae, can be found in Klimishin (1984). The calculations stopped when the postshock degree of ionization fell to a value $a = N_{H^+}/N_H < 0.001$. As a byproduct, we got also the intensity of the free–free emission of the postshock ionized gas.

The main result of the calculations is the time of the shock propagation in the stellar atmosphere until the moment when the shock loses its capacity to heat the gas to temperature that is sufficient for ionization. This time span is on the average about 1 month (from 20 to 35 days). This value is close to the duration of "humps" and "steps" on the ascending branches of miras' light curves. The subsequent growth of brightness is going on as if by inertia, at the expense of the growing volume of the expanding heated gas. It should be stressed that the relative duration of the noted features, expressed in fractions of the light period, is notably constant for different stars: it is, on the average, ~ 0.1.

The figures present sample light curves and some statistical regularities, which imply the plausibility of the suggested interpretation of the light curves. The table lists the stars used in the statistics.

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PERIODOGRAM ANALYSIS OF THE BRIGHTNESS VARIATIONS OF 8 RED SUSPECTED VARIABLES

V.I. Marsakova, S.V. Rottar, I.L. Andronov
Department of Astronomy, Odessa State University,
T.G.Shevchenko Park, Odessa 270014 Ukraine
E-mail: root@astro.odessa.ua

ABSTRACT. Eight red variables from the lists by Collins (1990, 1991) were measured on the plates of the Odessa plate collection. The results of the periodogram analysis are presented. TAV 0451+69 shows two oscillations with periods 242^d and 152^d. TASV 0714+39 shows 3–harmonic wave with $P = 403.2^d$.

Key words: Stars: semiregular, Mira–type

Observations and Preliminary Analysis

The new variable stars were measured on archive plates of the Astronomical Observatory of the Odessa State University by V.I.Marsakova (finding charts published by Collins (1990)) and S.V.Rottar (charts from Collins (1991)). The visual brightness of the comparison stars was used when measuring the photovisual plates ORWO ZP–3 exposed with a yellow filter. In some cases the values were corrected by using the arbitrary (st) scale. Such values are marked in Table 1 as $m(corr)$. The measurements on blue plates (ORWO ZU–21, without filter) were carried out by using the "st" scale only, as the stars are located far from the photometric standards. The light curves are shown at Fig. 1.

The characteristics of the light curves are listed in Table 3 in the order of right ascensions: n is the number of observations, max, min correspond to minimum and maximum, $< m >$ is the mean, σ_O is the r.m.s. deviation of the data from the sample mean. The results for 3 sub–intervals of observations of TASV 0413+31 are listed separately in Table 4.

The periodogram analysis was carried out by using the program FOUR–1 by Andronov (1994). All the stars were analyzed uniformly. At first the periodogram was computed for the original observations. Results are listed in Tables 3,4: f is best fit frequency, P is the best fit period, r is semi–amplitude, T_{Max} is the initial epoch (best fit moment of maximum closest to the sample mean time of observations), $S(f)$ is corresponding value of the test function, $-\lg(Pr)$ characterize Pr (the "false alarm probability", i.e. the probability of random occurence of the peak of the height more or equal than the observed) at one of the frequencies in the adopted range from 0 to 0.1 cycles/day.

Than a best sine fit was subtracted from the observations, and the periodogram was recomputed by using these "prewhitened" data. For the object TASV 0008+47 the best fit frequency is formally zero, thus the parabolic trend was subtracted from the observations. Another star TASV 0413+31 showed drastic brightness increase and thus we subdivided the data into 3 time intervals as shown at Fig. 1 with close (in time) points naively connected with lines.

The characteristics of the highest peak at the periodogram for $O - C$ are also listed in Table 3. Usually the peaks become less prominent and may correspond to a statistical noise.

Discussion

TASV 0008+47. No periodicites found. The significant trend towards lower luminosity was present during our observations onto which the aperiodic variations are superimposed.

Table 1. Brightness of the comparison stars

*	st	m_0	$m(corr)$
	TASV 0356+34		
a	0	10.5	10.54
b	4	11	10.93
c	6.71	11.2	11.19
d	9.21	11.4	11.44
	TASV 0413+31		
a	0	9.1	9.06
b	4	9.6	9.57
c	5.88	9.8	9.81
d	8.26	10	10.12
e	9.26	10.3	10.24
f	13.39	10.7	10.78
g	14.64	11	10.93
h	18.02	11.4	11.37

Table 2. Brightness of the comparison stars

*	st	*	st
*0008+47		*0451+69	
a	0	g	0
b	6.22	i	6.7
c	7.66	j	10.56
d	10.55	*1924+57	
e	11.99	a	0
f	12.42	b	1
*0714+39		c	2
c	0	d	4.25
d	4.35	e	6.25
e	8.8	f	8.5
g	10.65	g	10
		h	11.75

Table 3. Characteristics of the observed stars.

star	TASV 0008+47	TASV 0356+34	TAV 0451+69	NSV 02557	TASV 0714+39	TASV 0739+15	TASV 1924+57
Observer	SVR	VIM	VIM	SVR	VIM	SVR	SVR
n	134	94	57	60	98	66	50
Max	5.24^{st}	10.68^{m}	2.65^{st}	8.33^{m}	4.35^{st}	10.20^{m}	11.75^{st}
Min	7.66^{st}	11.94^{m}	15.14st	10.8^{m}	9.89^{st}	11.28^{m}	17.16^{st}
$< m >$	6.84^{st}	11.03^{m}	8.34^{st}	9.52^{m}	7.0^{st}	10.70^{m}	13.94^{st}
σ_O	0.52^{st}	0.15^{m}	3.56^{st}	0.50^{m}	1.6^{st}	0.22^{m}	1.24^{st}
$O:$							
f	0	0.00010	0.00413	0.03601	0.007709	0.011326	0.13913
		± .00001	± .00001	± .00002	± .000005	± .000002	± .00002
P	∞	9779	241.9	27.76	129.719	88.29	7.188
		± 1055	± 0.6	± 0.01	± 0.09	± 0.06	± 0.001
r	—	0.10	4.0	0.44	1.4	0.18	1.0
		± 0.02	± 0.5	± 0.07	± 0.2	± 0.3	± 2
T_{Max}	—	45976	45841	46251.8	39998	43078	45133.7
		± 344	± 5	± 0.8	± 2	± 3	± 0.3
$S(f)$	0.310	0.250	0.547	0.426	0.288	0.320	0.278
$-\lg(Pr)$	7.9	9.8	6.1	3.8	3.7	2.0	0.39
$O-C:$							
f	0.06589	0.01609	0.00660	0.00268	0.003003	0.153781	0.08091
	± .00006	± .00001	± .00001	± .00002	± .000006	± .000008	± .00002
P	15.17	62.13	151.6	372	333.0	6.5027	12.359
	± 0.01	± 0.04	± .3	± 2.26	± .7	± 0.0003	± 0.003
r	0.20	0.09	2.3	0.5	1.1	0.14	0.8
	± 0.05	± 0.01	± .3	± 0.2	± 0.2	± 0.03	± 0.2
$S(f)$	0.092	0.190	0.485	0.361	0.295	0.294	0.278
$-\lg(Pr)$	0.3	1.4	4.6	2.4	3.9	1.4	0.4

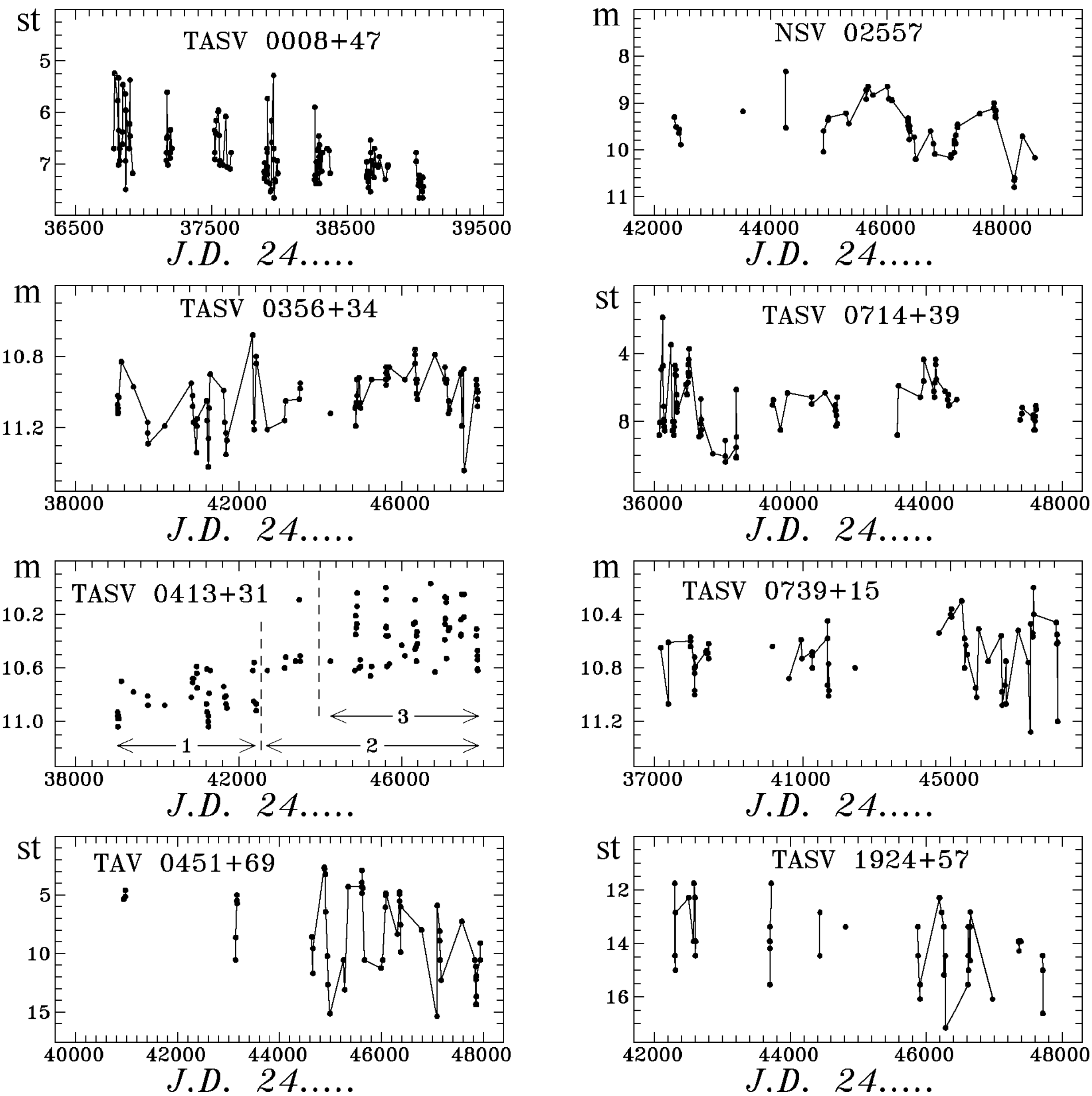

Figure 1. The light curves of the observed objects. The ordinate is in photovisual stellar magnitudes (m) when available or in arbitrary units (st). For the star TASV 0413+31 the whole interval was subdivided into 3 subintervals because of significant change of the mean brightness during our observations.

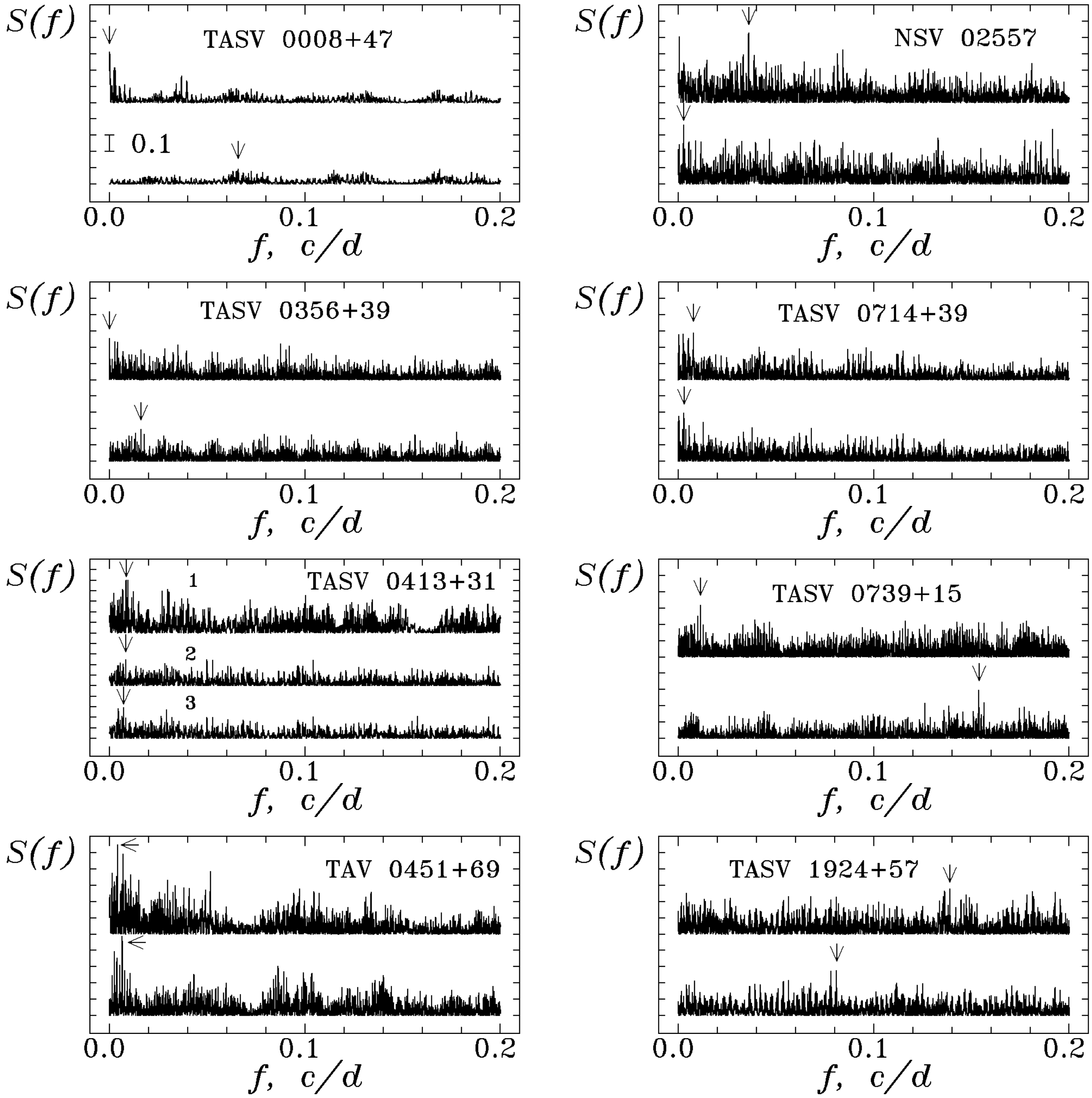

Figure 2. The periodograms $S(f)$ for the observations (up) and for the deviations $(O-C)$ (bottom of each figure) from the best sinusoidal fit. For the star TASV 0413+31 the periodograms are shown for the 3 time intervals marked at Fig. 1.

Table 4. Characteristics of the star TASV 0413+31 (Observer VIM)

Interval	(1)	(2)	(3)
n	37	63	57
Max	10.56^m	9.97^m	9.97^m
Min	11.04^m	10.66^m	10.63^m
$< m >$	10.82^m	10.35^m	10.34^m
O :			
σ_O	0.13^m	0.19^m	0.19^m
f	0.00861	0.00832	0.00729
	± .00003	± .00003	± .00004
P	116.1	120.1	137.2
	± 0.3	± 0.5	± 0.8
r	0.14	0.13	0.14
	± 0.03	± 0.3	± 0.3
T_{Max}	40729	46112	46422
	± 3	± 5	± 5
$S(f)$	0.500	0.246	0.289
$-\lg(Pr)$	2.3	0.7	1.2
$O-C$:			
f	0.13175	0.03198	0.04998
	± .00004	± .00003	± .0000
P	7.589	31.26	20.01
	± 0.002	± 0.02	± 0.01
r	0.08	0.13	0.12
	± 0.02	± 0.03	± 0.03
$S(f)$	0.386	0.326	0.294
$-\lg(Pr)$	0.8	2.5	1.6

TASV 0356+34. The 10000^d wave is statistically most significant. However, it may be owed to a 1 yr beat with more rapid variations. The periodogram analysis of 20 compact observations (JD 2440835–41708) shows a highest peak corresponding to T_{Max} = 2441203± 3^d, P =87.9± .8, r =.167± $.034^m$, $S(f)$ = 0.60. Deviation of the period value from that of 62^d listed in Table 3 may be owed to the cycle changes seen e.g. in the "short" interval.

TASV 0413+31. Significant increase of brightness by 0.6^m and of scatter from 0.13^m to 0.19^m occurred after JD 2442600. The whole data set was subdivided into 3 subintervals for which the periodograms were compared separately. The highest peaks appear at similar periods 116 – 137^d, although the formal error estimates are much smaller than the difference.

TAV 0451+69. Böhme (1992a) confirmed variability range (10.7^m – 14.5^m) on photovisual plates of the Sonneberg observatory taken in 1972-1990 and classified the object as a Mira–type variable with an ephemeris $Max.JD = 2441990 + 242^d \cdot E$ The highest peak at the periodogram for our observations (Fig.2, Table 3) occurred $P = 241.9^d \pm 0.6^d$ in excellent agreement with Böhme (1992a). However, similar analysis of the residuals showed a presence of another periodicity with $P = 151.6^d \pm 0.3^d$. By using a method of differential corrections for a two–frequency model (Andronov 1994), we obtained the following fit:

$$st_{pg}(t) = \underset{\pm30}{8.34} - \underset{\pm38}{3.73} \cos(2\pi(t - \underset{\pm4}{2445840})/\underset{\pm7}{242.4})$$

$$- \underset{\pm35}{2.33} \cos(2\pi(t - \underset{\pm4}{2445795})/\underset{\pm4}{151.7})$$

The highest peak at the periodogram for the residuals (O-C) from this two–frequency fit appears at $P = 11.914^d \pm 0.002^d$ with a much smaller amplitude 1.42 ± 0.27 which may appear due to a statistical fluctuation. Thus we confirmed main period of 242^d, but also detected another oscillations at 151.7^d.

NSV 02557. Brightness range $8.3^m - 10.8^m$ for our observations differs from that 9.4^m – 10.7^m of Collins (1991), indicating brightenings in our sample. The periodogram analysis shows a peak at $P = 27.76^d$ close to 1 Moon month indicating that it is possibly a beat period. Corresponding low–frequency part of the periodogram shows 2 peaks of similar height corresponding to periods 1587±29 and 1878±41 days. However, the same analysis of 47 more compact observations in the narrower range JD2444907–7865 gives fits with other periods:

$m_{pv}(t) =$

$$= \underset{\pm4}{9.50^m} - \underset{\pm6}{0.50^m} \cos(2\pi(t - \underset{\pm5.7}{2446636.4})/\underset{\pm2.0}{316.8})$$

and

$$\underset{\pm3}{9.44^m} - \underset{\pm5}{0.56^m} \cos(2\pi(t - \underset{\pm34}{2445701})/\underset{\pm92}{2501})$$

Corresponding r.m.s. deviations of the observations from the best fit curves are equal to

0.26^m and 0.22^m, respectively. Thus formally longer period fits observations better. Two-frequency fit shows that one of these peaks is a bias with 1 year, i.e. an alias due to the "observational window". Thus we may suggest that the real period is $P = 317^d$, but cycle-to-cycle changes of the phase curve are also present. To test possible asymmetry, we fitted the phase curve by trigonometric polynomials with different number of harmonics m (Andronov 1994). For various $m \leq 8$ we obtained best fit values of P from 315^d to 321^d, mainly closer to 317^d. Another wave with $P \geq 8000^d$ may also be present. The object may be classified as a semiregular variable with $P = 317^d$ during our observations. Variability at other time scales is also present.

TASV 0714+39. The "false alarm probability" estimate of both waves with $P_1 = 130^d$ and 333^d is low. The longer wave has an "1-yr" alias at 404.4^d, i.e. $\approx 3P_1$. The multi-harmonic analysis of the same data (Andronov 1994) showed the best fit period of $P = 403.2 \pm 0.3^d$, epoch of the maximum brightness JD 2439852 ± 3^d. Smoothed brightness at minimum is $9.6 \pm .7^{st}$, at max $4.9 \pm .3^{st}$. Although 3 harmonics were taken into account, the fit curve is symmetrical within error estimates.

TASV 0739+15. The periodogram for 34 more compact observations after JD 2444686 shows a highest peak at $P = 6.052 \pm .002^d$ and an amplitude $0.24 \pm .05^m$ ($S(f) = 0.41$). The periodogram for $O - C$ shows peaks of nearly equal height at $P = 88$, 24 and 7.9^d. The light curve argues for variations at a time scale of few (possibly 6–8 as seen at the perioogram) days, although they are not strictly periodic.

TASV 1924+57. Böhme (1992b) measured 202 photovisual plates of the Sonneberg Observatory and classified the object as a SRb variable with brightness variations from 10.3^m to 11.6^m, cycle length from 340^d to 420^d and an amplitude varying from 0.4^m to 1.3^m. From 8 moments of maxima he derived an ephemeris $Max.J.D. = 2445520 + 380 \cdot E$. Our periodogram analysis showed a highest peak apparently corresponding to much shorter time scale. The main period is not seen because of its signifiacant variability.

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STUDY OF THE VARIABILITY OF SOME GALACTIC B[E] STARS

A. S. Miroshnichenko
Central Astronomical Observatory, Pulkovo, Saint–Petersburg 196140 Russia,
E–mail: anat@gaoran.spb.su

ABSTRACT. The photometric investigation of B[e]–stars MWC 84, MWC 342, MWC 623, and MWC 930, close to them on spectral characteristics, has been made. A brightness variability in the optical and near IR regions has been studied. Regular parts of the variability were detected for all the objects. The variability mechanisms are considered. Binarity evidences for MWC 84, MWC 342, and MWC 930 are presented. A comparison of objects spectral energy distribution (SED) with star models having circumstellar shells was carried out and main system parameters have been defined.

Key words: Stars: emission–line, circumstellar matter, photometric variability, binaries.

The research program on strong emission–line objects with IR–excesses has been carried out jointly by the Central Astronomical Observatory of RAS and the Astrophysical Institute of Kazakhstan AS since 1984. Our results for B[e]–s MWC 84, MWC 342, MWC 623, and the related object MWC 930 are reported here. Photometric UBVRIJHK observations were made with the 1–m telescope of the Astrophysical Institute (Assy) using the photometer – polarimeter FP3U (Bergner et al. 1988) between 1988 and 1992. It was obtained about 60 observations of MWC 84, about 40 of MWC 623, about 100 of MWC 342, and 12 of MWC 930. Our colleagues from the Astronomical Institute of Uzbekistan AS obtained for us 90 UBVR observations of MWC 930 and nearly 200 of MWC 342 with 60–cm telescope at Mt.Majdanak during 1989–1990. Polarimetric RI and photometric observations were carried out quasisimultaneously with FP3U. About 50 ones for MWC 342 and not more than 20 for each of other objects were made. V.A.Lipovetsky acquired the spectra of MWC 84, MWC 342, and MWC 623 in 1986–1988, and the author obtained the spectra of MWC 930 and MWC 342 in 1989–1991 in the range of 4000-7000 Å using the scanner of the 6-m telescope of RAS. The dispersion was 50 and 100 Å/mm. Absorption features in the spectra of MWC 84, MWC 623, and MWC 930 are typical for late–type stars, while in MWC 342 they are of early–type. Photometric observations have shown that all the objects have brightness variability. Majdanak observations show that MWC 930 variability includes a regular part with 58.4 d period and amplitudes of about 0.1^m in VR–bands, and 0.4^m in B. For MWC 84 it was found the regular changes with 11.7 d period and the amplitude of 0.3^m. MWC 342 shows smooth brightness changes with 132 d period and the strongest amplitude of 0.6^m in U. Its polarization changes between 0.2 and 5% in the R–band with the period of 66 days. Photometric period of 5.1 d and the amplitude of 0.2^m. was detected for MWC 623 in UBV. Three of our objects signatures of both hot and cool star in their spectra. We have estimated main parameters of the stars and their shells comparing observed and theoretical SED by the method described by Bergner et al. (1990). The best fit for the SED of MWC 84 is B0 V + G8 II plus a dense gas and dust shell. Almost the same result we have obtained for MWC 930 (B0 V + K0 Iab–Ib). We suppose that MWC 342 is also a binary system with a hot (B0) primary and a compact secondary. The X–ray source 4U 2019+39 is situated in 19' of MWC 342 in UHURU error–

box. The best fit for the SED of MWC 623: B2 V+K7 III, Av=1.4^m, and the optically thin dust shell. The nature of its photometric variability remains unknown. Additional observations with more high spectral resolution and more wide spectral range are needed to obtain more refined models.

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GEOMETRICAL SCALE OF THE R CORONAE BOREALIS TYPE VARIABLES

A. E. Rosenbush
The Main Astronomical Observatory of Academy of Sciences of the Ukraine
Kiev-127, Golosiiv, 252127, Ukraine
E-mail: mars%gao.kiev.ua@ussr.eu.net

ABSTRACT. The radii of R CrB and RY Sgr are obtained on published radial velosity measurings: 90 radii of the Sun. They are not differed from the Feast' data. The distance of permanent dust shell unconnected with visual minima is estimated: 100 radii of star. A dust connected with visual minima is formed at the distance of about 60 radii of star.

Key words: Stars: R CrB: diameters – circumstellar dust.

THE SPECTRAL VARIATIONS OF VY MON IN 1986–1992

L. A. Pavlova
Fesenkov Astrophysical Institute, 480068 Almaty, Kazakhstan

ABSTRACT. The variations of the 3-component profiles of the spectrum of VY Mon are reported which may be explained by restricted models of variable anisotropic stellar wind.

Key words: Stars: young, mass loss, VY Mon.

The young star VY Mon is very variable object. The changes of brightness, emission line profile and polarization give the evidence of circumstellar envelopes existence where different physical processes such as: photoionization, outflow, accretion in dinamical inhomogeneous space take place.

VY Mon is one of the youngest four stars with infrared radiation excesses (LkHa 198, HL Tau, VY Mon, R Mon – Cohen and Schwartz 1976). The spectral data for VY Mon with enough resolution are not available but the data of Cohen and Kuhi (1979) with resolution 7 Å.

Our spectral observation program have been in 1986, the first spectragramms with resolution 2.7 Å show Ha emission line with P Cyg peculiarity. The estimate of mass outflow rate is $2 \cdot 10^{-6} M_{\odot}$/yr (Pavlova 1992).

Following results have been obtained during 1986–1992: three types of Ha profile can be seen in the spectrum: the profile with P Cyg absorption, the profile with blue emission and single emission profile. All three types are typical for the majority of the young Ae/Be Herbig and T Tau stars. In one object we can see some processes each of which take place in other stars. The measuring of the spectral features shows that displacement of peculiarity at first continuously increases and then decreases. We have not embraced the whole period of existence of each type profile, but in according to the last data receved in October 1992 – February 1993 the position of peculiarity continuously changes from –260 km/s to –350 km/s and then decreases to –155 km/s. This fact is very important for constructing of physical models of mass outflow. Preliminary estimation of the time of each type change is being during month or so, the duration of each stage is no less then four months. These variations may be regular and connect with light curve (Miroshnichenko et al. 1992). When VY Mon is seen as bright star ($V \approx 13^m$) the P Cyg–type peculiarity is observed, and when VY Mon is seen as weak ($V \approx 14^m - 15^m$) the profile has blue emission at first and then becomes the single. The whole cycle is as long as 3–3.5 yr. We have derived the systematic displace of the centre of the main emision for each type: +70 km/s for P Cyg, +120 km/s for the blue emission stage, +140 km/s for the single profile, but variations of its intensity relatively to continuum are weak. All three types imply that high-velocity outflows can be important envelope components and can be explained with the same limited models of anisotropic stellar wind, where therminal velocity is changed.

The flat infrared spectrum of VY Mon may signify the thin accretion disks, it is suggested that accretion rates are in range of $0.6 - 0.2 \cdot 10^{-5} M_{\odot}$ /yr (passive) and $3.5 \cdot 10^{-5} M_{\odot}$ /yr for active (Casey and Harper 1990).

Coexistense of accretion and outflow at the same time can lead to the situation rather dramatic for interpretation.

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CYCLE LENGTH CHANGES OF THE SRd VARIABLE UU HER ?

A.I. Pikhun, I.L. Andronov
Astronomical Observatory, Odessa State University,
T.G.Shevchenko Park, Odessa 270014 Ukraine, E–mail: root@astro.odessa.ua

ABSTRACT. Best fit periods for individual seasons show variations from 27^d to 101^d with a possible cycle $\approx 5500^d$. One – and multi– frequency sine approximations of 650 photovisual observations argue for a formal 2–component model with periods $P_1 = 44.92 \pm .06^d$, $P_2 = 70.37 \pm .16^d$ and semi–amplitudes $r_1 = 0.093 \pm .010^m$, $r_2 = 0.086 \pm .009^m$.

Key words: Stars: Semiregular: UU Her

UU Her was observed by A.I.P. on the archive plates of the Odessa collection obtained in JD 2436362–47716. Range of the brightness variations $8.46 - 9.23^m$ (pv), mean 8.88^m, r.m.s. deviation 0.20^m. The data were analyzed by I.L.A. by using the programs by Andronov (1994). The peak at the periodogram for $O - C$ (Fig. 1c) is statistically significant, thus a 2–frequency model was applied. Corresponding times of maximum brightness are HJD $2440651.3 \pm .7$ and 40701.53697 ± 1.4.

The period 71^d alternating with 90^d was noted by Beyer (1948). Latyshev (1966) published the value of 45^d. Both these periods are seen in our data. To study possible changes of P we subdivided the data into 29 "seasons" and computed the one–frequency periodograms. Dependence of the best fit periods in the range $20 - 100^d$ on time is shown in Fig. 2. Some values are apparently too small such as 20.7^d or even 10.6^d. Many times the peaks in the studied range are multiple. In this case primary and secondary peaks are shown. The value 80.1^d listed in GCVS (Kholopov et al. 1985) corresponds to the time interval 2443611–4161 with not sufficient number of our data. Fedotov (1987) obtained $P = 80^d$ for JD 2446170–6358. One may suggest both variations of the main period and the presence of at least two waves with different frequencies.

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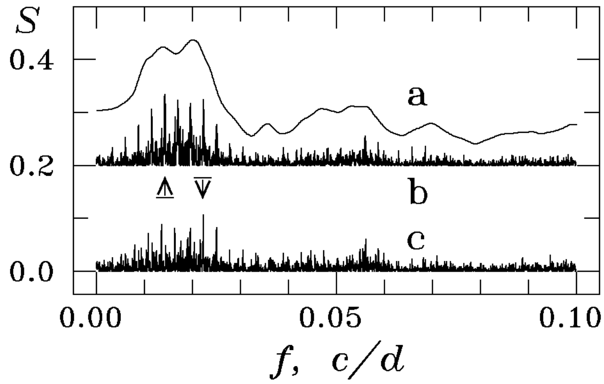

Figure 1. *a:* Weighted mean periodogram for 29 seasons scaled as $0.2 + 0.5\overline{S}(f)$; *b:* periodogram for all observations $0.2 + S(f)$; *c:* periodogram for $O - C$ (not shifted). Vertical arrows mark frequencies of the 2–component model.

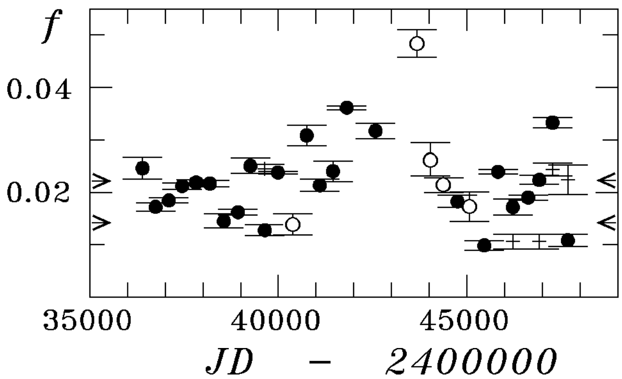

Figure 2. Best fit frequencies for individual seasons. Crosses correspond to second peaks, open circles to small $n < 10$. Horizontal arrows mark 2 "best" frequencies.

SYNTHETIC LIGHT CURVE OF R CORONAE BOREALIS

A. F. Pugach, G. U. Kovalchuk
Main Astronomical Observatory, Ukrainian Academy of Sciences
Golosiiv, Kiev 252127 Ukraine

ABSTRACT. The model for brightness variations of CrB is proposed.

Key words: Stars: R CrB

The so-called it "expanding model" of R CrB-type stars phenomenon which was elaborated in 1990-1993 is now capable of calculating light curve for any elementary light fading taking into account the solid carbon mass M of the dust cloud, its distance D (in a plane) from the star's center and the heterogeneity of the dust distribution. The it "synthetic light curve" would then be drawn as a superposition of numerous elementary light curves.

We have collected all available photometric observations of R Coronae Borealis covering the time span of 1850 - 1990 yrs and then tried to properly match the full observed light curve and the synthetic one. The preliminary result shows quite satisfactory coincidence at the majority of observed minima.

The synthetic light curve consists of 152 elementary light curves. Each of them was calculated using individual values of M, D and the moments T of onsets of the declines. Some important physical parameters might be inferred from a statistical analysis of M, D and T distributions.

1. The masses M of elementary dust clouds range within the limit of $1.3 \cdot 10^{20}$ g$\leq M \leq$ $2.7 \cdot 10^{23}$ g, average cloud mass of solid carbon being near $2 \cdot 10^{2}$ g. The total mass Md of solid carbon ejected from the R Coronae Borealis within 1850-1990 in the direction of the observer equals $Md \approx 1.7 \cdot 10^{24}$ g. However, the computed value of Md seems to be very underestimated (probably 2 -3 times) because of a non-monotony and a non- homogeneity of the dust distribution inside the clouds.

2. Distribution of the D-values can be fairly fitted by formula N = 40 exp[-0.66 D]. The formula reflects the quite obvious relation: the more mass M of the cloud the more distance D is. Not enough massive clouds seem hardly to absorb noticeable quantity of the parameter ΔT (ΔT is the time interval between the onset of two successive minima) has shown that the distribution of ΔT turns out to be very far from the uniform one. The values ΔT seem to form some peaks 1/2 A, B, A, 2B, 2A, 4B to be centered near time intervals: 1/2 A = 27.82 days; B = 39.28 days; A = 54.37 days; 2B = 77.44 days; 2A = 104.8 days; 4B = 152.7 days. Apparently all intervals are multiple to 38 and 54 days. On the other hand numerous direct photometric observations pointed out several periods of pulsations, the most pronounced of them being just close to 40 and 53 days. We interpret this distribution as being due to the presence of two independent periods of pulsations which are initiators of the dust forming process.

Thus the connection between the ΔT values and phases of pulsating process is established using *all available photometric data* covering time span 140 years. The reliability of the conclusion is believed to eliminate a certain ambiguity previously existed.

Conclusions:

1. During the history of photometric observations of R CrB at least 152 dust clouds turned out to be ejected from the star in a direction of observer.

2. The moments of the dust ejections are phased locked to the 40^d and 54^d periods of the pulsations.

3. The above-mentioned result rules out the possibility the dust clouds to be orbiting the star at the stationary orbits.

CEPHEID RADIAL VELOCITIES

N. N. Samus[1], A. S. Rastorgouev[2]
[1] Institute for Astronomy, Russian Academy of Sci.,
48, Pyatnitskaya Str., Moscow 109017 Russia, E-mail: samus@airas.msk.su
[2] Sternberg Astronomical Institute, 13, University Ave., Moscow 119899, Russia
E-mail ras@sai.msk.su

ABSTRACT. Some results of the programme of the measurements of the Cepheid radial velocities by using a correlational spectrometer are presented. The spectral binarity of the classical Cepheids MW Cyg and VZ Cyg is discovered. The orbital elements of the Population II binary Cepheid TX Del and of the classical binary cepheid DL Cas in an open cluster are determined more precisely. Preliminary orbital elements of MW Cyg are determined. By using the Baade–Wesselink method, the preliminary values of the radii of TX Del and DL Cas are determined.

Key words: Stars: Cepheids, radial velocities.

Since 1989 one of the programs being actively fulfilled with Tokovinin's (1987) correlational spectrometer is devoted to measurements of Cepheid radial velocities. The instrument is of CORAVEL type, it gives the possibility to measure radial velocities of stars in the F5 – M5 spectral type range down to 13th – 14th visual magnitude. For a 10^m star in the middle of this spectral type range we get the internal accuracy of approximately 0.3 km/s, with typical exposure times around 8 minutes, at 1 m telescopes. Cepheids are in the early type part of the spectral type range, but are readily measured. Radial velocities of Cepheids measured during the first 3 years of the programme were included in our catalogue (Gorynya et al. 1992a), based on 1546 measurements of 83 variables. Now we have added several more hundred Cepheid radial velocity measurements, so having acquired the world–richest series of high accuracy radial velocity observations of Cepheids. Our program has been so far naturally restricted to stars to the north of -25^o declination; though we find interest among colleagues in Chile and in South Africa, financial problems have not yet permitted us to observe there. By now we have observed in Russia, Bulgaria, Uzbekistan, and the Ukraine. The greatest volume of data for Cepheids has been gathered by us at the Simeiz Observatory.

We discovered two new spectroscopic binary Cepheids, MW Cyg (Gorynya et al. 1992b) and VZ Cyg (Samus et al. 1993). Fig. 1 shows the pulsational radial velocity curve of VZ Cyg. The change of γ-velocity by $\approx$ 7 km/s is evident. We tried to determine orbital elements for MW Cyg. By now there are two possible solutions, with periods of 191^d and 199^d and quite different eccentricities. This summer we have added many new observations and hope to be able to solve this problem.

We also rediscovered independently the spectroscopic binarity of TX Del, first found by Harris and Welch (1989), and improved its orbital elements. TX Del is a very interesting star. It has a pulsational period 6.166^d and an orbital period 133.15^d, very short for a binary Cepheid and thus restricting seriously the possible dimensions of the pulsating star. Fortunately TX Del is usually considered Population II Cepheid (so it must be smaller than classical Cepheids of the same pulsational period). However, the star has high metal abundance (Harris 1981), and in our observations it always shows rather high line contrast, not typical for Population II F-type stars.

This problem can be checked using one of modern modifications of the well-known Baade–Wesselink technique. We have analyzed possibilities of the existing versions if this

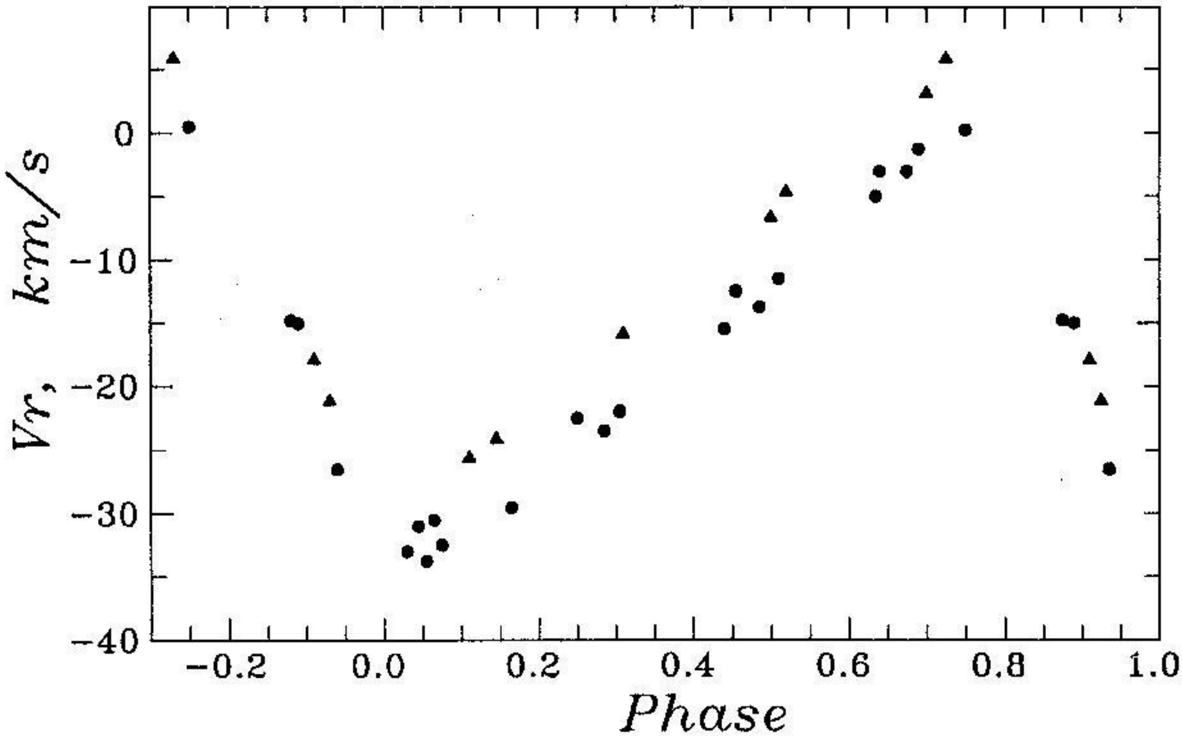

Figure 1: Radial velocity curve of VZ Cyg *vs* pulsational phase. Dots – the observations of 1992, triangles – the observations of 1993.

technique and found most promising to proceed on the base of the method described by Balona (1977). This method does not require selection of pairs of phases with equal effective temperatures, but rather takes use of the whole light and velocity curves. Our practise shows, however, that is might be better to exclude the ascending branch of the light curve with manifestations of shock waves and other phenomena difficult to account for. We also used software enabling us to check visually the quality of representation of observed light curves with model ones for adopted sizes of the star. Our version of Balona's technique was checked on several well-observed stars, like TT Aql, and gave very good results. Then we turned to complicated cases, like TX Del and a binary classical Cepheid DL Cas in the open cluster NGC 129 (we have also improved orbital elements for this star). For TX Del most reliable radius estimates are in the range 35–50 $R_\odot$, and for DL Cas – in the range 50–70 $R_\odot$.

Certainly, to get reliable results with any version of the Baade–Wesselink technique it is very important to have good photometry, preferably in red or infrared, and to be able to connect the systems of phases valid during intervals covered with photometry and with radial velocity measurements. Here we take full advantage of the excellent data base on Cepheid photometry created and kindly made available to us by L.N. Berdnikov.

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THE PULSATIONS OF RADIAL VELOCITIES AMPLITUDE OF V 474 MON - THE DELTA SCT TYPE STAR

S. N. Udovichenko, L. E. Lysova, O. P. Paramonova
Astronomical Observatory, Odessa State University
T.G.Shevchenko Park, Odessa 270014 Ukraine
E-mail: root@astro.odessa.ua

The variations of radial velocities amplitude of V474 Mon - the Delta Sct type star have been determined from spectrograms obtained at the 6-m telescope. Lines of metals are measured. The curves of radial velosities show both primary and secondary period variations, and a pulsation amplitude varies with the secondary period. Using the observations published earlier, the relationship between the radial velocity amplitude and the phase of the secondary period was obtained. The constant gamma-velocity does not confirm a suggestion that the system is binary.

Key words: Stars: pulsating; radial velocities; V 474 Mon

V 474 Mon is a star which has clearly marked peculiarities among the δ Sct type stars - a great amplitude of light variations, multiperiodic, radial and nonradial mode pulsation, a small *vsini*. Since the star was discovered as variable one in 1963 (Cousins, 1963) the detailed photoelectric observations and frequency analysis of light curves were obtained (Millis, 1973, Shobrock and Stobie, 1974).These observations allowed the authors to abstract from light variations curves three nonsinusoidal waves with the periods 0.13612^d, 0.1337^d and 0.13856^d. When these three pulsations superimpose two periods of light variations display most strongly: the primary with period of 0.136126^d and secondary - 7.74639^d (Romanov and Fedotov, 1979) . Because of this periods correlation the star looks like RR Lyr type stars (the main pulsation and Blazhko effect).

Even first observations of radial velocity of V 474 Mon by Jones (1966) show on variation of radial velocity amplitude from time. So far as there are few published observations of radial velocity, then correlation between radial velocity and secondary period is not investigated and the question about existence of tidal modulation (binarity of star) is not found out finally. Therefore the star have been observing to study in detail during some years by spectrograph of 6-m telescope of SAO RAS by group of observers: Yu.S.Romanov, S.N.Udovichenko, M.S.Frolov, B.N.Firmanjuk, L.P.Zaikova. This work is an extension of published earlier papers on investigation of radial velocities of V 474 Mon (Udovichenko, 1987, 1993).

For measuring of radial velocities spectrograms with dispersion 9 Å/mm were taken. Measurements have been carried out by comparator with oscilloscopic pointing on line with direct putting into computer (Udovichenko and Romanov, 1991). Analyzing spectrograms the dispersion curve was approximated by polynomial, radial velocities were reduced to the center of Sun. Determinations of velocities were carried out under 20-30 metal lines from each plate on the average; then were calculated average values on each plate and probable errors. The measurements of radial velocities of V 474 Mon for heliocentric Julian date of observations and probably errors of average value are given in Table 1.

The curves of radial velocities are drawn for three periods of observations on Fig.1. Phases of secondary period for these curves are found from the ephemerides:

$$J.D.max(O-C) = 2441664.962^d + 7.74639^d\, N$$

Table 1: The radial velocities of 474 Mon

H.J.D.	V_r hel	mean sq.err.	H.J.D.	V_r hel	mean sq.err.
2446688.502	33.2	0.6	.561	15.2	0.4
.508	32.5	0.4	.569	15.2	0.4
.521	19.7	0.4	.579	15.2	0.5
.526	17.4	0.4	.586	13.2	0.5
.531	12.0	0.5	.593	17.8	0.4
.536	9.8	0.4	.598	14.8	0.6
.539	11.0	0.6	.602	18.9	0.5
.545	7.8	0.3	92.493	20.4	0.4
.549	9.6	0.4	.499	19.9	0.6
.557	9.7	0.4	.504	14.4	0.3
.562	9.4	0.3	.509	13.9	0.3
.566	11.8	0.4	.513	12.4	0.3
.570	10.8	0.4	.518	11.1	0.5
.576	11.1	0.4	.523	9.9	0.5
.582	15.8	0.4	.528	10.1	0.3
.587	14.7	0.3	.532	11.1	0.4
.592	20.7	0.4	.536	9.7	0.4
.598	21.4	0.3	.540	9.7	0.3
.602	22.4	0.3	.544	10.2	0.3
91.504	29.0	0.6	.549	11.8	0.4
.509	28.4	0.5	.554	11.6	0.3
.513	29.3	0.6	.559	14.6	0.4
.518	24.4	0.4	.564	16.0	0.4
.523	24.6	0.3	.570	18.7	0.3
.526	25.0	0.5	.576	19.7	0.3
.534	21.4	0.3	.588	22.1	0.3
.542	19.0	0.3	.594	26.5	0.4
.551	15.8	0.4	.602	27.1	0.4

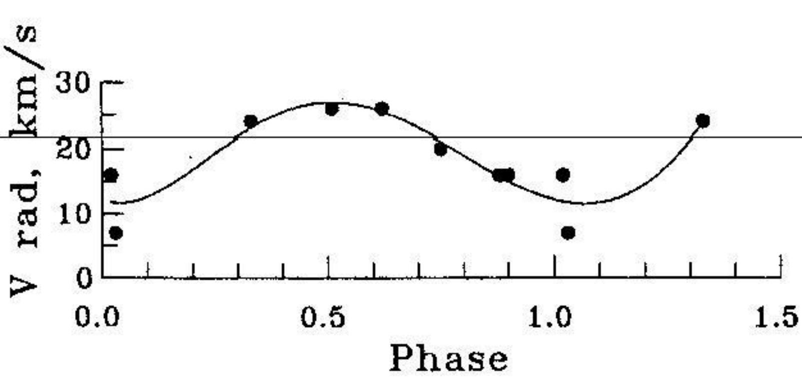

Figure 2: The variation of the radial velocity amplitude versus phase of the secondary period.

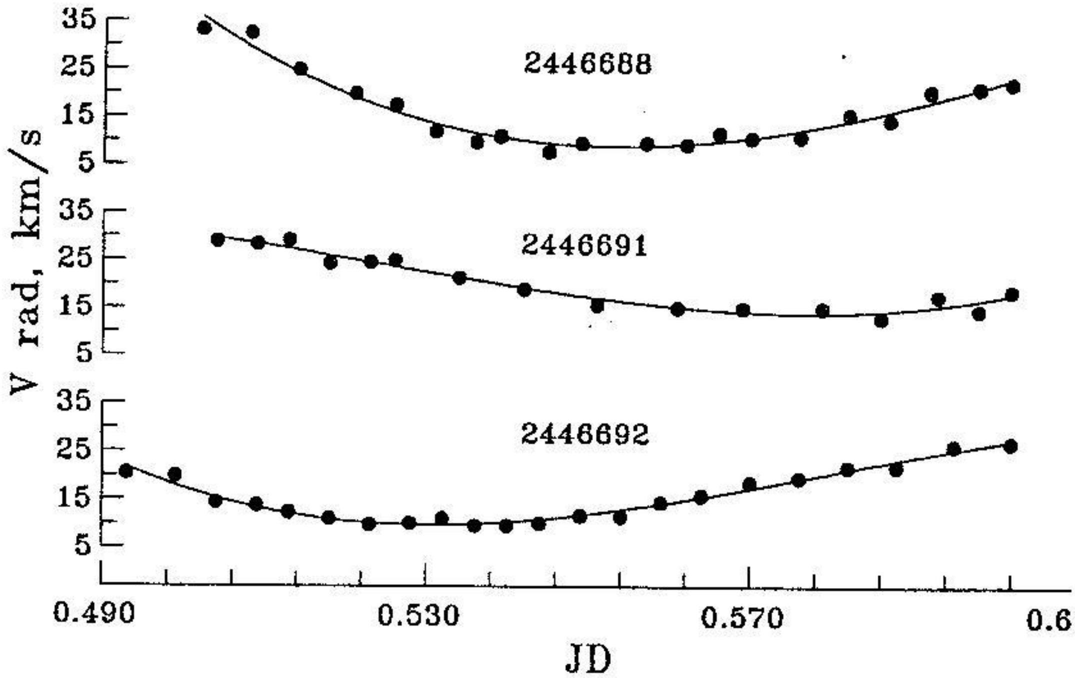

Figure 1: The radial velocity curves for three sets of observations. Numbers correspond to H.J.D.

(Romanov and Fedotov, 1979)

The curves of radial velocities' variations show a pulsation with the basic period of light star variation, and a pulsation amplitude varies with the secondary period. Using earlier published observations (Udovichenko, 1993), we received the variation of radial velocity amplitude (Table 2, Fig.2). For all curves gamma-velocity is 20±1.5 km/sec and do not vary, what does not confirm a lot of periods because of tidal modulation. The most probable cause of multiperiodic in star V 474 Mon is simultaneous excitation and interaction of some pulsations with similar frequencies.

Table 2: The variation of radial velocities amplitude

H.J.D.(mean)	Phase	Ampl.,km/s
2439103.49	0.33	24
2439139.44	0.03	7
2445984.52	0.62	26
2445985.55	0.75	20
2445986.54	0.88	16
2446688.55	0.51	29
2446691.57	0.90	19
2446692.57	0.02	15

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FREQUENCY ANALYSIS OF TWO-YEARS OBSERVATIONS OF RR LYRAE

A. V. Yushchenko, Yu. S. Romanov, N. D. Lemeshchenko, V. P. Murnikova
Astronomical Observatory, Odessa State University,
T.G.Shevchenko Park, Odessa 270014 Ukraine
E-mail: root@astro.odessa.ua

ABSTRACT. 2964 photoelectric observation of RR Lyrae were obtained at the Odessa observatory during two years: 1977 and 1978. Observations were transformed to standard BV photometric system and frequency-analyzed in the interval 0.08–700 days. A number of harmonics were detected. The main harmonic coincides with the well known photometric period (ν_0=1.764129), second harmonic (ν_B=1.789093) is related with a period of Blazhko effect. There is a sequence of harmonics, which can be written by equation $\nu = k\nu_0 + \nu_B$ where k=0,1,2,3,4. Two harmonics are connected with known periods of RR Lyrae: 123 days and four years.

Key words: Stars: individual – Stars: pulsation – Stars: RR Lyrae

The long series of photoelectric observations of RR Lyrae were published by Walraven (1949), Hardie (1955), Preston et al. (1965), Onderlicka and Vetesnik (1968).

Observations of Walraven (1949) and Onderlicka and Vetesnik (1968) were obtained in instrumental system and cover full curves of main period. Preston et al. (1965) observed in UBV system only maxima of light curves. We tried to obtain the full light curves of RR lyrae in standard BV system for different phases of Blazhko effect. Here after we give preliminary results of 14 years observations of RR Lyrae: two-years interval.

Two-colors photoelectric observations of RR Lyrae, numbering 2964, were performed with a photoelectric photometers attached to the 8-inch refractor and 20-inch reflector of Odessa astronomical observatory at observational station Mayaki. Observations obtained at two telescopes were reduced to the standard BV photometric system. We tried to obtain the full light curve at the different phases of Blazhko effect. The observations cover two years: 1977 and 1978.

Our data were frequency–analyzed by making use of Deeming (1975) method. We tried to investigate the complete light variations of RR lyrae. For this purpose we use the standard method of finding harmonics in light curves. We made frequency analysis, found the most powerful harmonic, the mean light curve corresponding to this harmonic was subtracted from data, and begun this cycle again. V, B and B-V values were processed independently.

Results of this procedure for B and B-V are shown in Table 1. The first four columns in Table 1 are the number of harmonic, period in days, frequency in cycles per day, amplitude. The last two columns of this table contain the possible interpretation of harmonic.

The first harmonic (ν_0) is a well known photometric period of RR lyrae. The second harmonic (ν_B) is connected with the period of Blazhko effect of RR Lyrae (41 day). Harmonics 2, 3, 4, 6, 7, 13 can be treated as a sequence:

$\nu = k\nu_0 + \nu_B$

where k=0,1,2,3,4.

Fifth harmonic (beating period 1186 days = 3.25 years) can be connected with a 3.8–4.8 year cycle of RR Lyrae. This cycle was found by Detre and Spreid (1973). We must to mention that our observation cover two years. The beating period of harmonic 14 is very close to 123-day period (Walraven, 1949) and can be

Table 1. Results of the frequency analysis of RR Lyrae.

	P (days)	ν	Ampl. (magn.)	$1/(\nu-\nu_0)$ (days)	Possible Interpretation
	B, 2964 observations in all phases of the main period				
1	0.566852	1.764129	1.00		ν_0
2	0.558942	1.789093	0.37	40.06	ν_B
3	0.141215	7.081391	0.20		$3\nu_0+\nu_B$
4	0.281429	3.553295	0.18		$\nu_0+\nu_B$
5	0.566581	1.764971	0.18	1186.94	
6	0.113059	8.844958	0.12		$4\nu_0+\nu_B$
7	0.188036	5.318124	0.14		$2\nu_0+\nu_B$
8	0.492173	2.031807	0.13		
9	0.281721	3.549613	0.11	271.60	
10	0.344821	2.900054	0.10		
	B-V, 2964 observations in all phases of the main period				
11	0.566848	1.764140	0.23		ν_0
12	0.558867	1.789326	0.09	39.70	ν_B
13	0.141212	7.081527	0.05		$3\nu_0+\nu_B$
	B-V, 1640 observations near maximum of the main period				
14	0.564359	1.771932	-	128.34	

treated as rotation period of RR Lyrae.

Harmonic 8 was not detected in V observations.

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SPECTROSCOPY OF VIRGINIDS

G. A. Galazutdinov
Special Astrophysical Observatory RAS
Nizhniy Arkhyz, Stavropol'skii Kraii, 357147 Russia
E-mail: vkloch@sao.stavropol.su

ABSTRACT. Spectroscopic observations of 10 W Vir-type stars were obtained at 6–m telescope by using the Echelle spectrometers ESPAC and Lynx. By using the method of model atmospheres the chemical composition was determined for V 351 Cep, BL Her, TX Del. Positional measurements of the lines formed in different layers were obtained for V 351 Cep.

Preliminary conclusions are the following: the sample of the observed virginids is not homogeneous. The objects of solar chemical composition were discovered for which the usage of the dependence "period–luminosity" (obtained for the halo cepheids) leads to the anomalous low luminosity values. These stars are not representatives of the II–nd type population. Few short–period virginids have secondaries seen in variability of the radial velocities. From the whole set of parameters, we may not classify these objects also as classical disk cepheids, because the light curve does not correspond to the dependence "period–phase curve" for classical cepheids.

Possible explanation of the observed properties of some short-period virginids is a hypothesis of their possible binarity. Or they belong to a class of "anomalous cepheids" which we propose to discuss as a result of the coalescence of the components in a close binary system.

Key words: Stars: Cepheids, Binaries

NEW DATA ON FAST VARIABILITY OF THE Hα PROFILE IN THE SPECTRA OF YOUNG Ae–Be HERBIG STARS FROM "P CYG" SUBGROUP

M. A. Pogodin
Central Astronomical Observatory, Pulkovo, Saint-Petersburg 196140 Russia

ABSTRACT. The variability of the Hα profile of 2 A0e Herbig stars HD 163296 (ESO, CAT+CES, July, 1991, 1992, 35 spectra) and AB Aur (CrAO, ZTSh + Coude-spectrograph, January 1993, 45 spectra). Significant variability of the P Cyg–type profile of both objects was detected with time scales from hours to months. Two main types of hour-scale variability are found: a) monotonous changes of arbitrary intensity of different parts of the line (both stars), b) episodic appearance of local spectral details at variable wavelength which may be owed to inhomogeneities of the circumstellar medium (HD 163296 only).

Periodicity of the profile of the absorption component in AB Aur with $P = 70^h$ an 35^h is suspected.

A simple geometric model of the circumstellar shell is proposed for similar objects with variable equator–concentrated stellar wind and a relatively quiet outer shell.

Key words: Stars: Herbig, HD 163296, AB Aur

PHOTOMETRIC CLASSIFICATION OF THE MARGONI & STAGNI SUSPECTED VARIABLES V 58, V 91

I. L. Andronov[1], A. V. Chikrigin[1], G. N. Kimeridze[2]
[1] Department of Astronomy, Odessa State University, T.G.Shevchenko Park, Odessa 270014 Ukraine
E-mail: root@astro.odessa.ua
[2] Abastumani Astrophysical Observatory, Abastumani 383762 Georgia

ABSTRACT. V 58 was found to be an eclipsing variable with $P = 0.46771^d(82)$, $T_{Min} = 2446421.795(5)$ and eclipse duration $d \approx 0.2P$. V 91 is a RRab type star with $P = 0.3493^d(11)$, $T_0 = 2446421.402(5)$, Max=13.32^m, Min=14.21^m, and an asymmetry $f = 0.26(2)$. Finding charts with photographic magnitudes of comparison stars are presented.

Key words: Stars: Eclipsing, Pulsating.

The objects discovered by Margoni & Stagni (1984) were observed photographically by using a 2–camera astrograph of the Abastumani Astrophysical Observatory in 1988 mainly by G.N.K. and I.V.Kharchenko. The blue–sensitive plates ORWO ZU–21 were used with a typical exposure time 25 min.

Previous one–time UBVRI observations showed that B–V colors are equal to 0.45^m for V 58 and 0.76^m for V 91 (Andronov et al. 1993), corresponding (according to the calibration of Johnson (1966)) to spectral classes ≈F5 and ≈G8, respectively. However, U–B colors for both stars occasionally correspond to earlier spectral types.

Brightness of the comparison stars was measured by A.V.Ch. by linking to the standard NGC 7063. These values are a=9.94(5), b=11.90(6), c=12.20(9), d=12.59(2) for V 58 and a=12.74(8), b=13.49(11), c=14.02(14) for V 91. Internal r.m.s. error in parentheses is expressed in units 0.01^m. However, the systematic difference is much larger. The only comparison star measured photoelectrically is very red object "c"="3" for V 58, for which the photographic estimate is more close to U (14.21) than to B (12.94). Time series analysis of the observations by A.V.Ch. was made by I.L.A.

V 58

Our light curves obtained during individual nights showed well pronounced eclipses. Moments of "weak" brightness near minima are listed in Table 1. A program "PERMIN" (algorithm described by Andronov 1991) allowed to obtain a best fit ephemeris listed in the Abstract. This value of the period is in agreement with Margoni's et al. (1989) suggestion that it is shorter than 1^d.

Table 1. Fadings of V 58

HJD 2446..	E	O-C
419.4615	–5	0.005
420.3956	–3	0.004
421.3156	–1	–0.012
426.4745	10	0.003

The phase light curve is shown at Fig.2. The smoothing line was obtained by using the method of "Running Parabolae" (Andronov 1990). with a filter half–width $\Delta t = 0.2P$ outside primary eclipse and $0.08P$ inside it. One may note no secondary minimum. The one–hump wave outside eclipse may be explained as a reflection effect. However, the orbital period twice the observed may also not be ruled out corresponding to an EB or EW–type binary with nearly equal minima. However, the amplitudes in EW stars are much smaller than the observed value 1.2^m.

V 91

Individual light curves are characteristic for RR Lyr – type stars. Two sure maxima were registered at HJD 2446421.4061 (13.41^m) and 422.4443 (13.25^m). Difference in brightness at maxima seems to be real and may possibly be explained by the Blazhko effect. We had made a 1–harmonic period search by using the method of the least squares, which allowed to obtain a preliminary period value $P = 0.3478 \pm 0.0014^d$. However, the phase curve (Fig.2) showed significant asymmetry f, and we computed best fit period values for m – harmonic approximation (Andronov 1994). Estimates of f varied from 0.26 ± 0.02 ($m = 3$) to 0.33 – 0.36 for other $1 < m < 8$. The fit for $m = 3$ corresponds to statistically significant number of harmonics. Brightness at the mean extrema is 13.32(5) and 14.21(6). One may note that a "hump" at the descending branch is not real. It apparently occurred due to a phase shift of the lower maximum (421) in respect to higher (422) one. Other parameters are listed in the Abstract. For comparison, we describe the 2–harmonic fit. It shows no hump (Fig. 2), it corresponds to a period $P = .3496 \pm .0016^d$, epoch $T_{Max} = 2446421.419 \pm .007$ which are the same within the error estimates as the values for other fits. However, the asymmetry $f = 0.36 \pm .02$ is underestimated.

Results on study of these objects on the astrograph plates of the Sternberg State Astronomical Institute will be presented elsewhere.

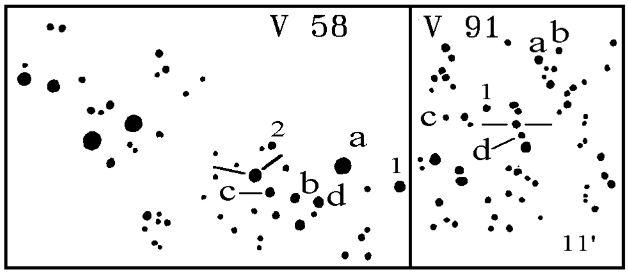

Figure 1. Comparison stars. The magnitudes are (Andronov et al. 1993): U=11.53, B=11.40, V=11.05, R=10.77, I=10.52 (V 58, N 1); U=12.93, B=12.69, V=12.05, R=11.54, I=11.11 (V 58, N 2); U=14.21, B=12.64, V=11.66, R=10.72, I=11.00 (V 58, N 3); U=12.92, B=12.31, V=11.40, R=10.69, I=10.11 (V 91, N 1).

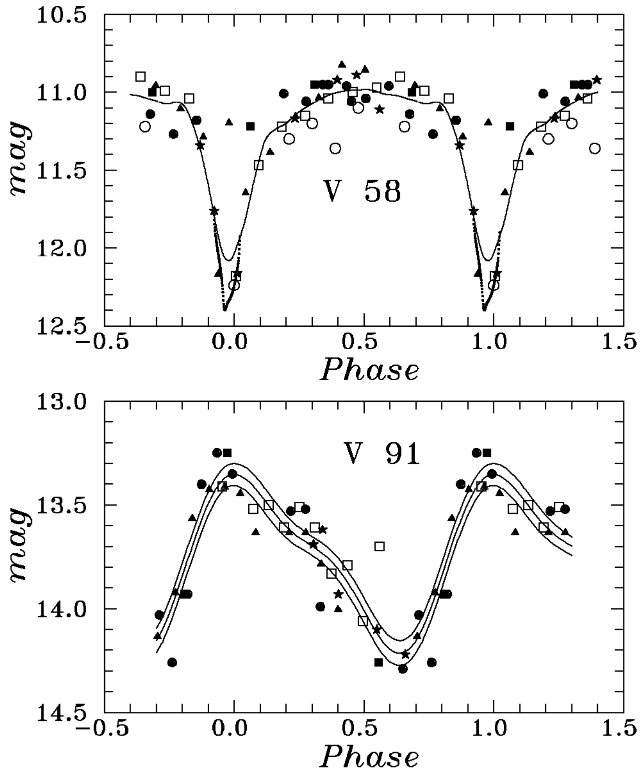

Figure 2. Light curves. The observations obtained at different dates are marked by symbols: ⋆ – JD 2446419, – 420, ∆ – 421, • – 422, ■, o – 426. Solid line is a fit obtained for V 58 by the method of "running parabolae" (Andronov 1995) with $\Delta t = 0.2P$. Small points from phase –0.078 to 0.022 correspond to $\Delta t = 0.08P$ better fitting the minimum. One bright point at mid–eclipse was not used. For V 91 the lines correspond to 2–harmonic fit $m(\varphi)$ and to $m(\varphi) \pm \sigma(\varphi)$.

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DUPLICITY AMONG RR LYRAE TYPE–STARS

V. P. Bezdenezhnyi
Astronomical Observatory, Odessa State University,
T.G.Shevchenko Park, Odessa 270014 Ukraine

ABSTRACT. On the basis of the analysis of small amplitude O–C variations, seven RR Lyrae variables are detected as possible binaries. It appears, that each one of these has probably a close companion. By using a proximate iterative algorithm, some parameters of their orbits were estimated. An evolutionary status of these stars are considered.

Key words: Stars: RR Lyrae stars, light–time effect, duplicity hypothesis

The problem of duplicity among RR Lyrae type stars is of great importance both for theory of stellar evolution and for pulsation theory. Many authors have been studying it. For example, Coutts (1971) investigated the light–time effect among cepheids and RR Lyrae stars in globular cluster M3. She made a conclusion that nearly 20 per cent of RR Lyrae type variables in M3 belonged to binary systems. It would seem not grounded, as only for one star V13 in M3 the cycle wave is repeated several times. In other cases, only arcs can be seen in the O–C diagrams; moreover their amplitudes are about a few decimal of days. There is no agreement with the duplicity hypothesis, as very large orbital (and radial) velocities of RR Lyrae stars and masses of second components are obtained. Until recently we haven't known any candidates to binary systems among RR Lyrae field stars. At least, there seems to be no physical restrictions on their presence in wide pairs. Apparently, all depends on the exactness of observations and of the small effect.

Bezdenezhnyi (1985,1988) revealed cyclic oscillations of mean O–C residuals with small amplitude on the time scale a few years for V363 Cas and X Ari, and then – for DX Del and WCVn (unpublished). Also, we paid attension to this effect for RR Gem, that can be seen from Goranskij (1982) figure, using Szeidl's (1975) observations. In the recent work Saha et al. (1990) showed, that fluctuations of O–C residuals TU UMa could be explained according to the duplicity hypothesis. They obtained preliminary solution with a very eccentric orbit (e>0.90) and the period of about 7400 days. Behaviour of mean radial velocities satisfies qualitatively for this hypothesis too.

In the present investigation we suggest an iterative proximate–method for estimation of masses, semimajor axes and orbital velocities of companions, one of them is the variable star, and another may be invisible, by assuming circular orbits.

A periodical pulsating or eclipsing star is supposed to have a far distant invisible component. Then the variable would move around its common mass centre of a multiple system, and observed extrema in its light curve would precede or lag behind those computed. Due to the periodicity of an orbital motion, behaviour of O–C residuals will prove to be periodical too, and judging from it the conclusion can be drawn on the parameters of the multiple system.

If in analyzing plots of small amplitude of cyclic variations in O–C residuals, a semiamplitude is determined as A_{O-C} (relative to the mean line set by a true period of the variable), the light equation will be written as follows:

$$a_v = A_v \sin i = \frac{86400 c A_{O-C}}{R_\odot}. \quad (1)$$

By substituting A_{O-C} in days, $R_\odot$=696000 km and light velocity we obtain the value of a semimajor axis for the variable in units of the Sun's radius:

$$a_v = 37241\, A_{O-C}. \quad (2)$$

By using the generalized third Kepler's low:

$$a = 0.01957(M_1 + M_2)^{1/3} P_{orb}^{2/3} (AU), \quad (3)$$

where $M_{1,2}$ are given in units of solar mass and the period in the mean solar days. We transform this formula by expressing a semimajor axis of the relative orbit a in units of solar radius:

$$a^3 = 74.426(M_v + M_{co}) P_{orb}^2. \quad (4)$$

Masses of the variable and a companion are given in units of the solar one. The length of a cycle (in days) of a long–term small amplitude O–C oscillation is taken for the period of orbital motion. We introduce the parameter q equal to the ratio of the companion mass to the variable star mass:

$$q = \frac{M_{co}}{M_v} = \frac{a_v}{a_{co}}. \quad (5)$$

Then the total mass of the system is:

$$M = M_v + M_{co} = M_v(1 + q), \quad (6)$$

and a semimajor axis is:

$$a = a_v + a_{co} = \frac{a_v(1 + q)}{q}. \quad (7)$$

Substituting these expressions into equation (4) we obtain:

$$a_v^3 \frac{(1 + q)^2}{q^3} = 74.426 M_v P_{orb}^2. \quad (8)$$

Let us introduce the parameter:

$$\alpha = \frac{(1 + q)^2}{q^3} = q^{-1} + 2q^{-2} + q^{-3}, \quad (9)$$

the product of which by the mass function is equal to the mass of the variable star: $\alpha f(M) = M_v \sin^3 i$. Then formula (8) will be of a simple form:

$$\alpha a_v^3 = 74.426 \, M_v \, P_o r b^2. \quad (10)$$

Making an assumption relative to M_v, for RR Lyrae stars we adopt M_v=0.6$M_\odot$, if a more precise value is not known for the given star, according to formulae (2) and (10) the value of α –parameter is found, whereas by formula(9) that of the q–parameter – by iterative method. Then M_{co} and a_{co} can be estimated as well as velocities of orbital motion of components with the precision up to a muitiplier $\sin i$.

The results of using the method for seven RR Lyrae stars are displayed in Table 1. As is seen from it, the distance between components is represented in a rather wide range (2.7 – 10 AU). Masses of companions are mainly more than those of RR Lyrae stars except for V13 in M3. For X Ari using the mean parallax π = 0.023" from the works by Manduca et al.(1981) and Jones et al. (1987) the angular distance of components was estimated a=0.013". For V13 π=0.0001" taken from Kholopov (1955) gives a=0.0007", that is the objects seem to be unresolved. Invisibility of companions is indicative of their faint light and their belonging to old evolved objects, white dwarfs or, even, to neutron stars. It also suggests an idea of an eruptive process of Novae in the binary system and favours for the arguments outlined by Saha & White (1990) relative to TU UMa.

Moreover, the data tabulated indicate a proportional relation between ΔS and a: metallicity has a tendency of increasing in stars in closer pairs. This elucidates the evolutionary status of these stars and is suggestive of explaining some anomalies in RR Lyrae stars of disc and halo constituents. High metallicity of V363 Cas can be accounted for large mass companion and relatively small distance from it.

The impression is produced that RR Lyrae stars are representatives of a Population II of the Galaxy with a metal–poor abundance. And only the influence of the environment (galactic gas in the disk and in the cluster, or ejections during the explosion of the evolved companion) increases metal abundances in their atmospheres.

Literature sources Preston (1959), Woolley et al.(1966), Eggen (1964), Joy (1938) and Thompson (1984) from mean radial velocities of X Ari do not seem to provide very ample material (–40, –44, –33, –40, –37, km/sec) which is of no contradiction to our estimations.

We would suggest replenishing the classification of RR Lyrae stars with objects which

Table 1.

Star	A_{O-C} (d)	P_{cycl} (d)	M_{co} $(M_\odot)$	$v \sin i_{co}$ (km/s)	$v \sin i_{RR}$ (km/s)	$a \sin i_{co}$ (AU)	$a \sin i_{RR}$ (AU)	$a \sin i$ (AU)	ΔS
V13 M3	0.03	6250	0.45	6.7	5.0	3.8	2.9	6.7	6.4
TU UMa	0.05	7374	0.65	5.6	6.1	5.8	4.2	10.0	7.6
RR Gem	0.03	2722	0.95	6.9	10.8	1.7	2.7	4.4	3.0
X Ari	0.04	4012	0.93	6.1	9.4	2.2	3.5	5.7	8.5
V363 Cas	0.03	1450	1.92	6.1	19.5	0.8	2.6	3.4	1.0
DX Del	0.02	1275	1.05	8.4	14.8	1.0	1.7	2.7	2.6
W CVn	0.03	2899	0.81	7.2	9.8	1.9	2.6	4.5	7.0

show small amplitude cyclic variations in O–C in the time scale for some years as being binary systems.

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SUGGESTED VARIABILITY TYPES OF SUPERNOVA PROGENITORS

O. A. Tsiopa

Central Astronomical Observatory, Pulkovo, Saint-Petersburg 196140 Russia

ABSTRACT. Recent theoretical computations of the evolutionary tracks of massive stars do not allow to check the presence of variability of the stars just before the outburst. However, the complex inner structure of such stars (stratification of chemical elements, shell sources) allows to create conditions for pulsation instability which may play a role of rigger. Existing long-term radio observations of SN 1979C argues not only for presence of ejected matter, but for periodic (≈ 4000 yr) modulations of the mass loss rate. Early optical spectral observations of SN 1984E, 1983K, 1990M argue for self–consistent interpretation as a shell–like structure of superwind (intensive stellar wind ejected during few years before the outburst). Ellipsoidal distribution of dynamic velocities of the wind shells may be owed to large radial pulsations of the progenitors with amplitudes different at the equator and the poles. Early radio emission of SN 1987A has no single explanation. In a case of plasma mechanism one has to accept a "blobby" wind structure. Inhomegeneities are more significant at large distances. Thus most interesting and informative are the fast variations of absorption profiles formed near and mainly before SN maximum.

Key words: Stars: Supernovae, Progenitors

ON THE POSSIBLE TRIPLICITY OF THE BINARY SYSTEM UU SAGITTAE

V. P. Bezdenezhnyi
Astronomical Observatory, Odessa State University,
T.G.Shevchenko Park, Odessa 270014 Ukraine

ABSTRACT. On the basis of the photographic observations of the Algol-type eclipsing variable UU Sge has been revealed the light-time effect in the O–C diagram. Probably, it has been evoked by the third close (1.6 AU) invisible companion.

Key words: Stars: Algol–type binary, light-time effect

According to a modern GCVS classification (Kholopov et al. 1987), this eclipsing variable belongs to the Algol type (EA). It consists a main sequence star (KV) and a subdwarf of the spectral type O. The degenerate companion is the nucleus of the planetary nebula Abell 63.

This variable has been investigated by Tsessevich (1976) and Bezdenezhnyi on the basis of the Moscow and Simeiz photographic plate collections. The mean curve shows the large reflection effect. To our 10 mean moments of the minimum brightness the epoch of minimum has been added according to Bond et al. (1978), these elements being given by Kholopov et al. (1987). O–C residuals are calculated from our elements:

$$Min.H.J.D. = 2432797.283 + 0.4650697 \cdot E \quad (1)$$

The O–C residuals seem to have a cyclic change with a long period (736 days) and an amplitude of about 0.02 days. The reduction of the O–C residuals to one cycle has been performed by the formula:

$$\Psi = \frac{E}{736} - N, \quad (2)$$

where N is the cycle number. This reduction is satisfactory. Table 1 and Figure 1 give the results of this study.

The light-time effect in the O–C diagram of UU Sagittae revealed has probably been evoked by the third close companion. The estimate of the semimajor axis of the eclipsing variable in the triple system is 1.6 AU.

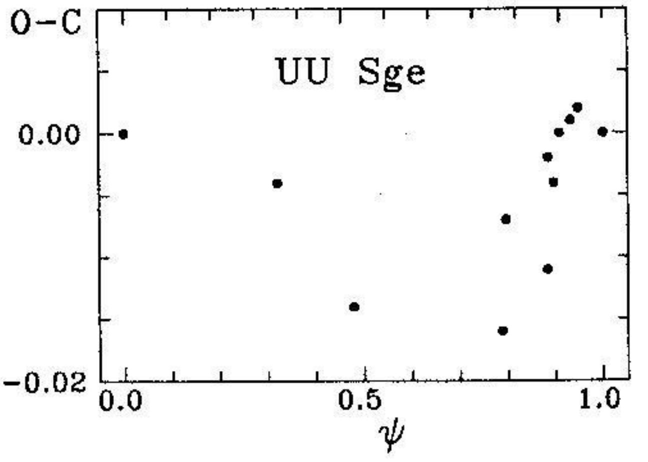

Figure 1. The reduction of the O–C residuals to one cycle according to formula (2).

Table 1.

Min.H.J.D.	E	O–C	Ψ
2432797.283	0	0.000	0.000
2433033.534	508	–0.004	0.321
2433447.439	1398	–0.011	0.883
2433448.379	1400	–0.002	0.884
2437163.358	9388	+0.001	0.931
2437176.381	9416	+0.002	0.948
2440512.310	16589	–0.014	0.479
2440819.266	17249	–0.004	0.896
2441475.468	18660	–0.016	0.788
2441564.312	18851	0.000	0.908
2442953.933	21839	–0.007	0.796

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DETECTION OF NONTHERMAL OPTICAL FLARES FROM A BURSTER MXB 1735-44 AND X-RAY NOVA PERSEI 1992 = GRO J0422+32

C. Bartolini, O. Benvenuto, G. Beskin, C. Feinstein, A. Guarnieri, M. Mendez, S. Mitronova., S. Neizvestny, A. Piccioni, V. Plokhotnichenko, M. Popova, A. Zhuravkov
Special Astrophisical Obsevatory, Russia

ABSTRACT. During the observations on the 2.15 m telescope of CASLEO observatory (Argentina) two flares of about 0.25s duraion were detected from a burster MXB 1735-44. their forward fronts had steep regions with characteristic times of 0.05 - 0.06s and thin time structure within 0.005 - 0.006s with confidence probability > 95%. Brightness temperatures of these phases of the flares were more than $10^8 - 10^{10}$ K respectively. During the observations of Nova Per on the 6 m telescope of SAO stochastic flashes on a time scale from 10-20ms to 200s were recorded. The brightness temperature of the shortest flares were more than $(1.7\text{-}7.0)\cdot 10^8$ K. The events detected from these objects with high probability may be caused by nonthermal prosesses only. The rezults evidence probable departures from standard model of gasodynamic accretion on compact objects in MXB 1735-44 system and Nova Persei 1992.

Key words: Stars: Flares, Bursters, X-Novae

AM HERCULIS IN A LOW STATE OF BRIGHTNESS (SEPTEMBER, 1991)

J. M. Bonnet-Bidaud[1], M. Mouchet[2], T. A. Somova[3], N. N. Somov[3]
[1] Service d'Astrophysique, DAPNIA/SAp,F-91191,Gif sur Ivette Cedex France
[2] Meudon Observatory, 92290 Meudon, France
[3] Special Astrophysycal Observatory, Nizhnij Arkhyz, 357147, Russia

ABSTRACT. The results of spectral and photometric observations of the polar AM Her at the 6-m telescope of the Special Astrophysical Observatory (RAS) on 4/5 and 5/6 September 1991 are presented. The spectra were obtained with a TV scanner (Drabek et al. 1986) mounted on the spectrograph SP-124 at the secondary focus (N1) in the wavelength range (3950 – 4950 Å) with the spectral resolution 2Å. Photometric UBVR measurements and light curves in the filter B with a temporal resolution of 0.1 s, using NEF photometer (Vikulev et al. 1991), were also performed. AM Her was observed in filter V on September 4th at a magnitude of 15.757($\pm$0.006) and on september 5th at 15.152($\pm$0.003), that is in a low state of brightness. On September 4th, the weak emission lines of hydrogen and absorption Zeeman components were seen in the spectra. The spectra show strong changes after one day. On September 5th, the lines of higher excitation He II 4686, He I appeared. The equivalent widths of the hydrogen lines increased by a factor 3 and their relative intensities by a factor 1.5, while the Zeeman absorption lines decreased by a factor 2–3. Using the absorption spectrum of Zeeman hydrogen splitting, a magnetic field of ($\approx$ 10 MGs) is estimated.

Quasi-periodic oscillations with a period of 397 sec and an amplitude of 6–8% during 30 min were registered in the light curve of September 5th. The spectral and photometric behaviour of AM Her show that it was in the transition from low to intermediate state of brightness. These new observations confirm that (5–7 min) oscillations are characteristic of the AM Her brightness transition as suggested in previous work (Bonnet-Bidaud, Somov, Somova 1992; Somova & Somov 1992; Bonnet-Bidaud, Somova, Somov 1991; Somova, Somov, Bonnet-Bidaud 1992).

Key words: Stars: Cataclysmic

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FAST-TIME SPECTROSCOPY AND PHOTOMETRY OF THE AM HER-TYPE SYSTEM AN UMA (MARCH 1991 AND JANUARY 1992)

J. M. Bonnet-Bidaud [1], M. Mouchet [2], T. A. Somova [3], N. N. Somov [3]
[1] Service d'Astrophysique, DAPNIA/SAp, F-91191, Gif sur Ivette Cedex France
[2] Meudon Observatory, 92290 Meudon, France
[3] Special Astrophysical Observatory, Nizhnij Arkhiz 357147 Russia

ABSTRACT. AN UMa has been observed at the 6-meter telescope of the Special Astrophysical Observatory on 10–11 March 1991 and 28 January 1992. Spectroscopic and photometric data were obtained simultaneously. Spectra were acquired using a TV scanner (Drabek at al. 1986) with the spectrograph SP-124 in the wavelength range (3950–4950 Å) with the spectral resolution 2 Å. Photometric UBVR measurements and light curves in filter B were performed at NEF photometer (Vikulev et al. 1991) with a temporal resolution of 0.1 s. The behaviour with the orbital period of the hydrogen and helium emission lines profiles (Hβ, Hγ, He II 4686), equivalent widths, relative intensities, half-widths and velocities was investigated. The velocity of the peaks and the centers of gravity of emission lines were used for the velocity curves with the orbital period. Analysis of the velocity curves shows a significant phase shift (0.20 cycle) with respect to the ephemeris period of Liebert et al. (1982), due to the inaccuracy of the orbital/rotation period. From a re-analysis of all the published spectroscopic data for the narrow-line components, a new ephemeris for the 'blue-to-red gamma crossing time' was determined:

$$T(HJD) = 2443191.0255 + 0.07975282^d \cdot E$$
$$\pm 24 \qquad\qquad \pm 4$$

With this new period, we find that all the published photometric light curves are also correctly phased over more than 15 yr (Bonnet-Bidaud et al. 1992). High speed photometric data were used to search for temporal variations. The quasi-periodic oscillations (QPO), which are similar in frequency and amplitude to those reported by Middleditch (1982) and Larsson (1985, 1987, 1989), were detected in 102.4s segments of data. The amplitude of the QPO varies from 1.6 to 4% with a frequency width of 0.25 to 0.50 Hz (FWHM) around a centroid frequency which is only slightly variable from 0.6 to 0.72 Hz (1.4 to 1.7 s). No significant variation of amplitude with orbital phase was detected. On short intervals of time, the QPO pulsed fraction varies from 1 to 5% rather erratically. The observed QPO are most probably trains of low coherence oscillations (less than a few tens of cycles) rather than superposition of persistent low amplitude coherent pulsations with different frequencies.

Key words: Stars: Cataclysmic; Polars; AN UMa

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OUTBURST DECLINE OF SLOW NOVA RT SERPENTIS (1909) FROM 1940 TO 1993.

V. V. Bochkov[1], E. P. Pavlenko[1], O. P. Vasiljanovskaja [2]
[1] Crimean Astrophysical Observatory
[2] Institute of Astrophysics, Academy of Sciences of Tajikistan

ABSTRACT. We present observations of the Nova RT Ser (1909) from 1940 to 1978 (photograhic magnitudes) and from 1983 to 1993 (B, V, R). Light variations with typical time of 10 years have been detected. Brightness declines at a rate of 0.06 magnitude per year during last 70 years..

Key words: Stars: Novae - symbiotic stars - photometry.

Introduction

RT Ser was discovered on the Harvard plates during its 5300 day rise from 16 to about 9 visual magnitude (Shapley 1919). The nova remained at maximum visual light for few years before beginning a tediously slow decline.

This object was listed by Payne–Gaposchkin (1957) as one of the slowest of all classical novae and it was classified as the prototypical symbiotic nova by Kenyon (1986). Infrared observations show that this symbiotic star contains a normal M giant (Feast and Glass 1974). An M6 spectral type to the giant component on the basis of the 2.3 micron CO absorption band was assigned by Allen (1980).

A photographic outburst light curve up to 1936 was given by Payne–Gaposchkin and Gaposchkin (1938). Here we present the Gissar photographic observations from 1940 to 1978 and the B, V, R photometry, obtained in the Crimean Astrophysical Observatory (CrAO) from 1983 to 1993.

Observations

RT Ser have been regularly observed in the CrAO at the 0.5–meter meniscus telescope (F=6.5m), equipped with a sensitive TV system, since 1983. An image intensified isocon LI–804 tube was used as a detector. Field of view is about 10×10 arc minutes. The diameter of used photocathode's part is 22 mm. Dry cold air is used to cool the tube up to $\approx 0°$ C.

Eight stars were selected in the observed region as secondary photometric standards (Fig. 1). Their instrumental b, v, r magnitudes were obtained with the method described by Prokof'eva et al. (1993). and based on absolute calibration of TV observations by using artificial stellar images. Extinction derived from the observations of extinction stars was taken into account to reduce the observations of RT Ser.

For seven nights the instrumental v magnitudes were obtained by using another method. According to this method the investigated region (near RT Ser) and the photometric standard (galactic cluster NGC 188) were observed by using the same regimes of TV technique and with minimal time interval (less than 20 minutes in our case). Then the calibration curve for NGC 188 was used to determine the stellar magnitudes of stars near RT Ser. The value

$$\Delta m = (Fz_1 - Fz_2)\cdot\alpha \qquad (1)$$

must be added to the derived magnitudes because Here Fz_1 - air mass of NGC 188, Fz_2 - air mass of RT Ser, α - the extinction coefficient of the existence of the difference in air mass between the two regions.

The instrumental b, v, r magnitudes are transformed to standard B, V, R magnitudes of Johnson and Morgan's photometric system by using the reduction formulae by Prokof'eva

Table 1: Brightness of the comparison stars for RT Ser

Star	V	σ_V	B–V	σ_{B-V}	V–R	σ_{V-R}
1	14.43	0.05	1.53	0.08	1.87	0.06
2	14.19	0.05	1.29	0.07	1.70	0.05
3	14.81	0.06	1.00	0.07	1.65	0.06
4	14.77	0.05	1.04	0.08	1.64	0.06
5	15.31	0.07	1.15	0.08	1.97	0.09
6	13.45	0.07	1.66	0.08	1.99	0.08
7	14.57	0.07	0.68	0.08	1.64	0.07
8	15.13	0.06	0.77	0.08	1.59	0.07

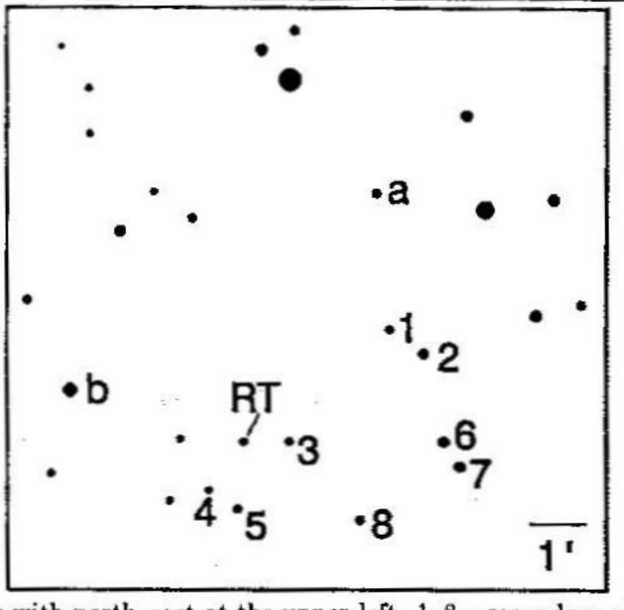

Figure 1: Region near RT Ser with north–east at the upper left. 1–8 – secondary photometric standards, a,b – stars, used in reduction of Gissar photographic observations to B standard band.

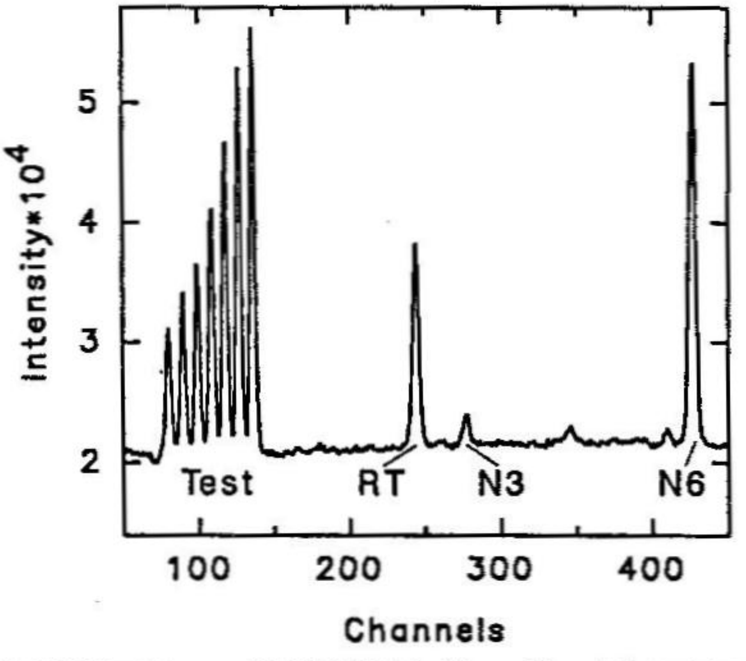

Figure 2: TV record of RT Ser taken on JD 2448400.5 in filter r. From left to right: seven artificial stars images (test), RT SER, star N3, star N6.

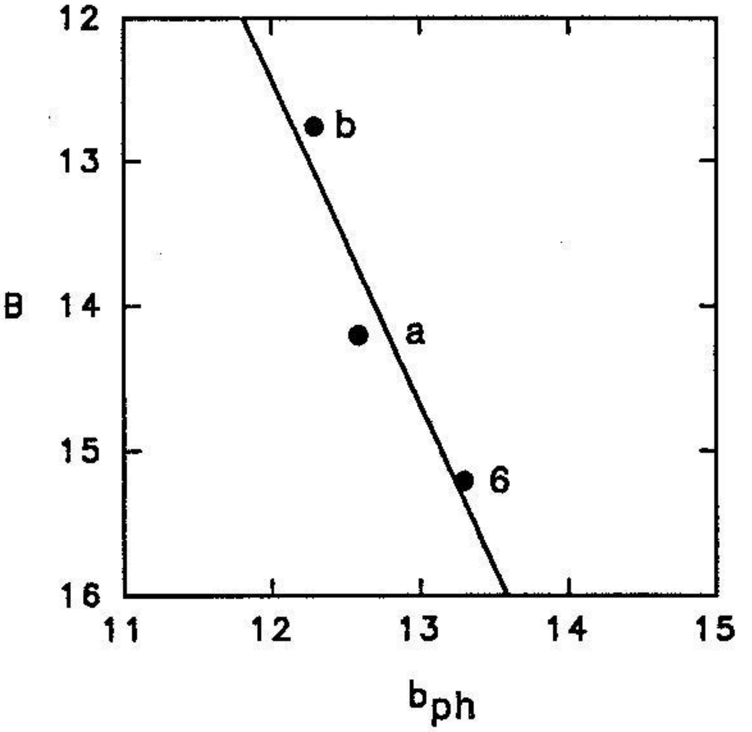

Figure 3: Connection between photographic magnitudes (b), obtained in Gissar observatory and B magnitudes of standard photometric system.

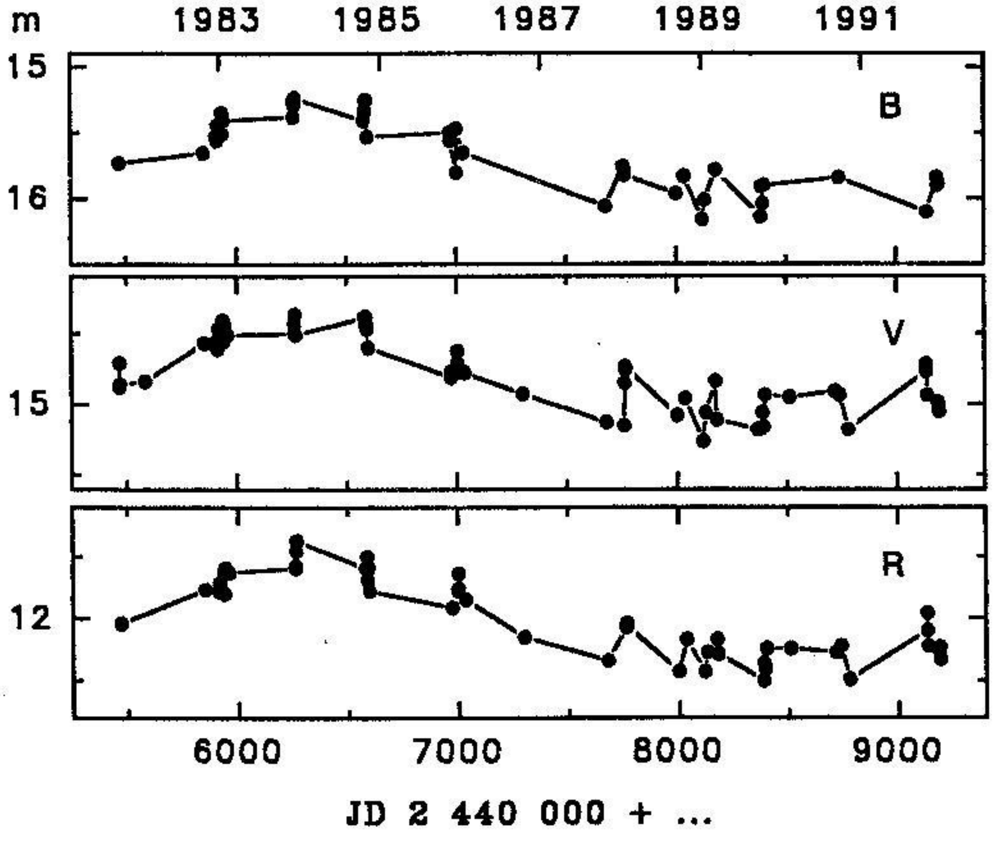

Figure 4: B, V, R photometry of Nova RT Serpentis (1909).

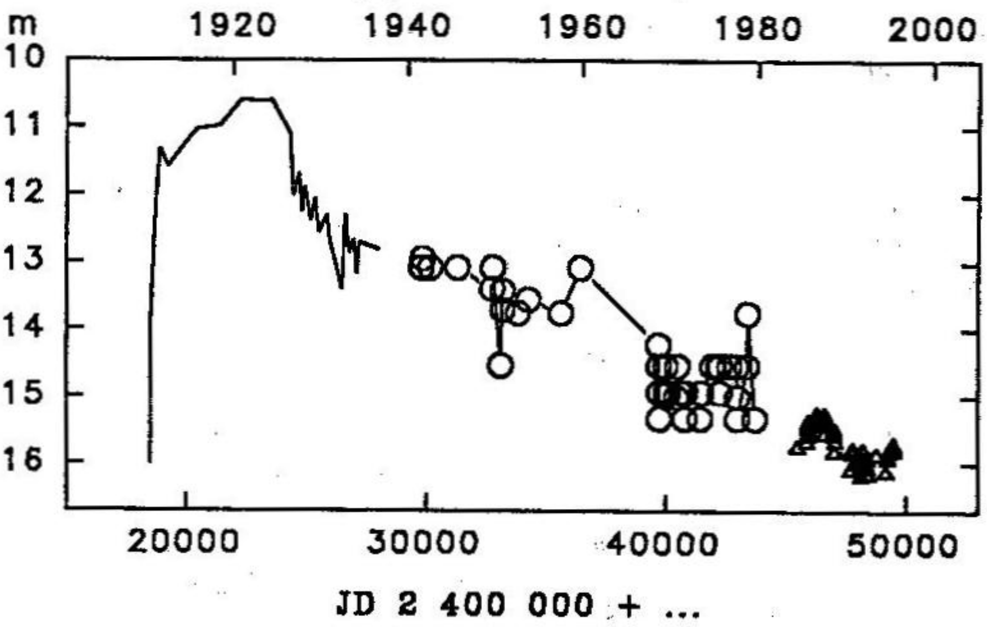

Figure 5: Optical light curve of Nova RT Serpentis (1909). Observations: line – Harvard, circles – Gissar, triangles – Crimean Astrophysical observatory.

et al. (1993).

The V magnitudes and B–V, V–R color-indexes and their root mean squared errors of the secondary standards are listed in Table 1.

The image of the observed region on the monitor was photographed with camera during first seven years: from 1983 to 1990. Stellar images of nova and neighboring stars were measured with the microphotometer MF–2 having constant diaphragm. The instrumental magnitudes of RT Ser were derived from the characteristic curve fitting the secondary standards. The accuracy of the observed data are about 0.05 mag for V magnitudes and 0.09, 0.06 mag for B–V and V–R colors respectively.

From the beginning of 1990 the brightness of RT Ser and one or two comparison stars was recorded in digital form. Special technique select the part of every TV line, summarize the whole energy of this part, and then transform the energy to digital form. In that way the strobe are formed on every TV card. The strobe size on TV line is about 9 seconds of arc. The strobe size of whole card is 600 channels. An example of the TV record is displayed at Figure 2. There are present photometric contours of seven images of the artificial stars (test), RT Ser, star N3, star N6 in the strobe.

The logarithm of the square of a contour is used as the measure of the whole energy, kept by the photocathode from the star. Images of seven artificial stars with known brightness (calibrating marks) are projected onto the input photocathode of TV pick up tube during exposures. They are used for photometric calibration of TV records. The accuracy of observed data are about 0.04 mag for V magnitudes and 0.07, 0.04 mag for B–V, V–R color-indexes, respectively.

To complete the curve of the RT Ser outburst, we used photographic observations obtained in Gissar observatory from 1940 and to 1978. These observations were obtained with Industar–17 camera (F = 50 cm, A = 1:5).

Vasiljanovskaja looked through more than 1000 plates and could measure the brigthness of RT Ser only on 43 plates. To reduce the photographic magnitudes to B spectral band of Johnson and Morgan's photometric system, Vasiljanovskaja had make visual measurements of the stars from the region around RT Ser observed at the TV complex. This reduction is shown in Fig. 2. Stars, named as *a* and *b* (Fig. 1) are very bright at the TV images, so they haven't been included in the group of secondary standards because of low accuracy of their V and R magnitudes.

Results

The light curve of RT Ser obtained from 1983 to 1993 in B, V, R color bands is displayed in Figure 4. Light variations with typical time of ten years are present in these bands. The whole amplitudes are 0.94, 0.89, 1.13 mag in B, V, R bands, respectively. The B–V, V–R color-indexes vary in a range of 0.5 mag and their mean values are 0.90, 2.78 respectively.

To display the whole picture of development of the outburst of RT Ser, three groups of observations are plotted in Figure 5. Line – Harvard photographic observations published by Payne–Gaposchkin and Gaposchkin (1938), circle – Gissar photographic observations, reduced to the B band, triangles – television observations in the B band. The complex light curve demonstrate the brightness decline at a mean rate of 0.06 mag per year during last 70 years. The brightness variations of a few tenths of the stellar magnitude are probably present with characteristic time of decades of days.

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PHOTOMETRIC STUDY OF TY CRA

V. S. Shevchenko[1], E. A. Vitrichenko[2], P. S. The, D. de Winter[3]
[1] Astronomical Institute, Tashkent, Uzbekistan
[2] Space Research Institute, Moscow, Russia
[3] Astronomical Institute 'Pannecoek', Amsterdam, Netherlands
E-mail: mnatenzo@esocl.bitnet

ABSTRACT. The UBVRI photometric data of TY CrA have been compiled mostly unpublished. The new period and epoch have been derived: Min I = JD 2442954.301+2.888782·E. The errors are about 2 units in the last digit. At the first time the V light curve have been solved. The elements are: $r_1 = r_2 = 0.13$, $L_1 = 0.92$, $i = 81.7^o$. The light curve has no phase effect. No color variation have been seen. There is some depression near phase 0.5. If it is real, the relative surface brightness evaluation leads to conclusion that the secondary may be a F0 star with 2 $M_\odot$.

Key words: Stars: Binaries: Eclipsing.

TIME SERIES ANALYSIS OF THE AFOEV OBSERVATIONS OF SYMBIOTIC STARS UV AUR, TX CVN AND V 1329 CYG

L.L. Chinarova[1], I.L. Andronov[1], E. Schweitzer[2]
[1] Astronomical Observatory, Odessa State University,
T.G.Shevchenko Park, Odessa 270014 Ukraine, E–mail: il-a@mail.ru
[2] Association Française des Observateurs d'Etoiles Variables (AFOEV)
11, rue de l'Université, 67000 Strasbourg, France, E–mail: afoev@simbad.u–strasbg.fr

ABSTRACT. One – frequency sine approximations allowed to obtain the following best fit parameters: periods $P = 389.23 \pm 0.47^d$, 3779 ± 73^d, 958.7 ± 1.2^d mean brightness $a = 9.23 \pm 0.02^m$, 9.73 ± 0.01^m, 13.26 ± 0.07^m. semi–amplitudes $r = 0.92 \pm 0.026^m$, 0.02 ± 0.007^m, 0.49 ± 0.10^m and epochs for mean maxima $T_M = 2446551.4 \pm 1.8$, 7014 ± 21, 5345 ± 3^d for UV Aur, TX CVn and V 1329 Cyg, respectively. Extreme values and cycle lengths vary with time, their characteristics are tabulated.

Key words: Stars: Binaries, Symbiotic, UV Aur, TX CVn, V 1329 Cyg.

Introduction

Detailed analysis of observations of these stars on photographic plates of the Sternberg State Astronomical Institute (SAI) in Moscow are presented by Chinarova (1995). Tables of the individual photographic data were published by Hric et al. (1994) as a part of large international campaign initiated by Hric and Skopal (1989). Reviews on the structure and evolution of these objects one may find e.g. in Boyarchuk (1983) and Kenyon (1986).

Here we discuss results based on the visual observations from the AFOEV database described by Schweitzer (1993). Statistical characteristics (number of observations n, times of start and begin of the run t_1 and t_n, sample mean $\overline{m}$ and a r.m.s deviation σ_O) are:

*	n	t_1	t_n	$\overline{m}$	σ_O
UV Aur	650	3934	9098	9.08^m	0.79^m
TX CVn	1340	3302	9168	9.68^m	0.24^m
V 1329 Cyg	1617	0890	9166	13.22^m	0.44^m

Methods for data reduction

For a more precise determination of the period we used a computer code FOUR–1 described by Andronov (1994). The light curve was approximated by a trigonometric polynomial

$$m(t) = a_0 + \sum_{k=1}^{j} (a_k \cos(2\pi f_k t) + b_k \sin(2\pi f_k t)),$$
$$= a_0 - \sum_{k=1}^{j} r_k \cos(2\pi f_k (t - t_{Mk})), \qquad (1)$$

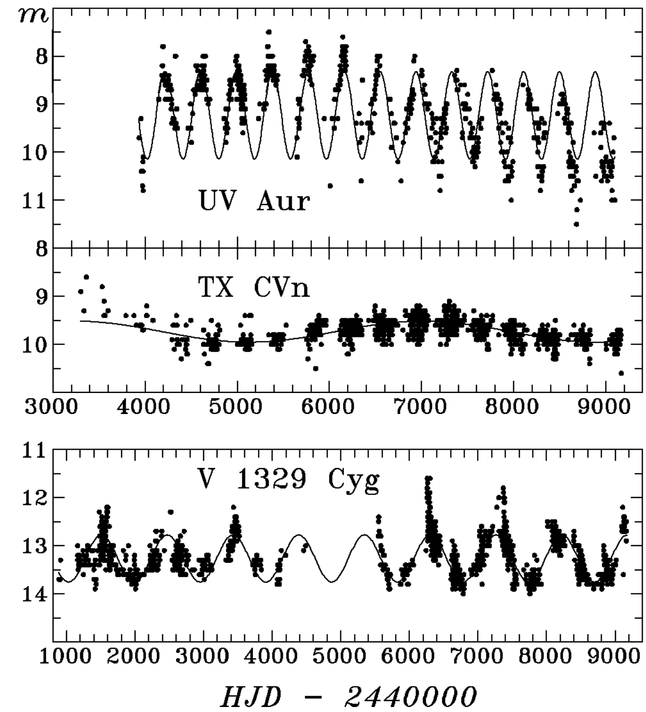
where $m(t)$ is a smoothed value of the brightness m at time t. Coefficients a_k $(k = 0...j)$ and b_k $(k = 1...j)$ are determined by using the method of least squares for fixed values of frequencies f_k. Semiamplitude of variations at each frequency is equal to $r_k = (a_k^2 + b_k^2)^{1/2}$. As a test function for trial frequencies $f_k = 1/P_k$, we have used

$$S(f) = \frac{\sigma_C^2(f)}{\sigma_O^2} = 1 - \frac{\sigma_{O-C}^2(f)}{\sigma_O^2}, \qquad (2)$$

where σ_O^2, $\sigma_{O-C}^2(f)$and $\sigma_{O-C}^2(f)$ are variances of the "observed" signal (O), "calculated" value (C) and of the deviations "observed–calculated" ($O - C$) for a set of f $(f_1...f_j)$. For each j the "best fit" value(s) of period(s) were computed precisely by using the method of "differential corrections".

Light curves are shown in Fig. 1,2. Periodograms corresponding to one–frequency models are shown in Fig. 3. Best fit parameters are listed in the Abstract.

To study variability in the individual cycles we use the method of "running parabolae"



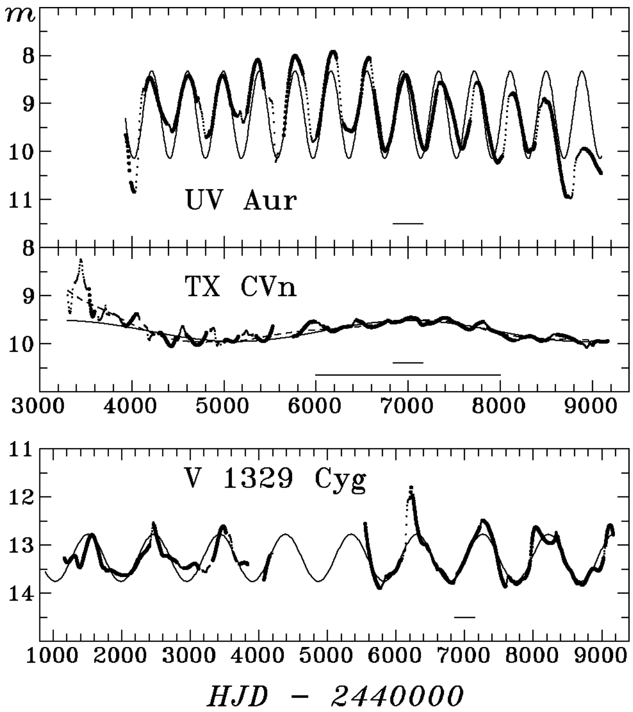


Figure 1 (left). Light curves of UV Aur, TX CVn an V 1329 Cyg. Filled circles are original observations, line is a best sinusoidal fit.

Figure 2 (right). Smoothed light curves. Large points correspond to a "good approximation" by using the method of "running parabola" (RP), when there are ≥ 3 data points locate closer than $0.3\Delta t$ from the trial time. Small points correspond to worth accuracy when the data are far from the trial time. Full time interval $2\Delta t$ is marked by corresponding horizontal bars. For all stars $\Delta t = 160^d$. Additional dashed line for TX CVn shows a RP fit with $\Delta t = 1000^d$ corresponding to long–term changes.

Table 1. Characteristics of the maxima of UV Aur obtained by "running sines" and "running parabolae" fits

T		E	ϕ		mag		$n_{0.5}, n_{0.1}$		σ_{O-C}	r		T_{RP}		m_{RP}	
4184	± 43	-6	-.08	±.11	8.43	± .11	41	12	.31	.49	± .11	4193	± 9	8.46	± .07
4614	8	-5	.02	.02	8.41	.04	47	28	.22	.68	.09	4613	6	8.42	.04
4990	4	-4	-.01	.01	8.42	.05	83	28	.26	.78	.08	4985	4	8.42	.05
5364	5	-3	-.05	.01	8.11	.05	47	31	.25	.92	.12	5367	5	8.09	.05
5781	6	-2	.02	.01	8.00	.04	47	27	.25	.95	.08	5772	5	8.01	.04
6177	7	-1	.04	.02	7.92	.07	54	29	.33	.94	.07	6186	5	7.92	.05
6564	4	0	.03	.01	8.06	.07	42	6	.24	.95	.06	6572	5	8.05	.07
6969	6	1	.07	.02	8.33	.09	43	3	.29	.75	.07	6969	7	8.40	.08
7374	9	2	.11	.02	8.46	.12	55	6	.36	.70	.08	7354	12	8.56	.11
7751	6	3	.08	.01	8.46	.12	52	2	.29	.83	.08	7750	17	8.55	.11
8146	15	4	.10	.04	8.81	.15	53	7	.42	.71	.10	8141	2	8.79	.09
8477	9	5	-.05	.02	8.64	.17	54	3	.38	.82	.09	8479	2	8.90	.10
8935	129	6	.13	.33	9.94	.15	32	6	.45	.31	.15	8902	134	9.94	.22

Table 2. Moments of minima of UV Aur obtained by "running sines" and "running parabolae" fits

T		E	ϕ		mag		$n_{0.5}, n_{0.1}$		σ_{O-C}	r		T_{RP}		m_{RP}	
4021 ±	12	-7	.50 ±	.03	10.68 ±	.31	16	0	.34	1.20 ±	.21	4032 ±	5	10.86 ±	.42
4407	12	-6	.49	.03	9.70	.14	50	0	.30	.57	.09	4439	10	9.60	.20
4807	8	-5	.52	.02	9.79	.14	50	0	.23	.70	.09	4811	7	9.72	.16
5164	7	-4	.44	.02	9.73	.14	86	0	.30	.76	.08	5210	4	9.40	.16
5563	3	-3	.46	.01	10.67	.21	42	0	.22	1.29	.11	5563	4	10.22	.46
5977	5	-2	.52	.01	9.93	.14	57	2	.26	.98	.08	5967	17	9.79	.38
6379	8	-1	.56	.02	9.76	.11	41	5	.33	.89	.09	6383	18	9.58	.14
6765	7	0	.55	.02	10.00	.11	30	4	.29	.81	.10	6749	8	9.99	.15
7172	7	1	.59	.02	9.95	.07	48	12	.33	.79	.08	7182	9	9.96	.09
7582	12	2	.65	.03	9.90	.06	45	19	.30	.65	.08	7586	5	9.95	.06
7956	11	3	.61	.03	10.23	.08	43	17	.36	.84	.10	7970	10	10.23	.11
8329	23	4	.57	.06	10.06	.12	46	13	.41	.62	.09	8310	9	10.01	.11
8743	13	5	.63	.03	11.17	.23	41	1	.40	.90	.13	8718	10	10.94	.23

Table 3. Middles of ascending and descending branches of UV Aur obtained by "running sines" and extrema of V 1329 Cyg from the RP fit.

T		E	ϕ		mag		$n_{0.5}, n_{0.1}$		σ_{O-C}	r		T_{RP}		m_{RP}	
UV Aur: middle of the ascending branch												V 1329 Cyg: maxima			
4116 ±	4	-7	.74±	.01	9.49±	.18	41	1	.27	1.07 ±	.08	1317 : ±	13	13.22 ±	.05
4519	12	-6	.78	.03	9.05	.08	53	8	.27	0.64	.08	1564	9	12.79	.04
4893	8	-5	.74	.02	9.19	.07	83	15	.27	0.76	.08	2463	6	12.53	.16
5271	7	-4	.71	.02	8.93	.09	57	4	.24	0.80	.08	3478	9	12.61	.03
5676	5	-3	.75	.01	9.11	.06	46	11	.23	1.13	.10	6190	8	12.04	.13
6081	5	-2	.79	.01	8.88	.07	48	9	.26	0.99	.08	7265	11	12.48	.10
6472	7	-1	.80	.02	8.91	.07	43	16	.33	0.86	.08	8037	12	12.63	.05
6865	7	0	.81	.02	9.17	.07	36	14	.27	0.85	.08	8335:	3	12.72	.07
7265	10	1	.83	.02	9.21	.09	48	14	.36	0.74	.08	9121	15	12.59	.08
7672	12	2	.88	.03	9.30	.12	49	2	.29	0.62	.07				
8056	10	3	.87	.03	9.53	.18	42	0	.36	0.68	.09				
8407	19	4	.77	.05	9.48	.20	58	0	.41	0.51	.08				
8839	32	5	.88	.08	10.40	.31	33	1	.40	0.50	.14				
UV Aur: middle of the descending branch												V 1329 Cyg: minima			
4310±	16	-6	.24±	.04	9.14±	.08	45	17	.33	0.61 ±	.09	1390 : ±	6	13.46 ±	.07
4711	10	-5	.27	.03	9.10	.10	50	3	.22	0.69	.08	1793	7	13.54	.03
5082	12	-4	.22	.03	9.08	.06	79	32	.27	0.64	.08	2086	18	13.63	.05
5463	4	-3	.20	.01	9.48	.14	48	2	.24	1.44	.12	2923	97	13.48	.05
5873	6	-2	.26	.01	8.96	.14	44	0	.27	0.97	.09	5769	8	13.91	.07
6280	4	-1	.30	.01	8.84	.12	58	1	.30	0.95	.06	6827	5	13.78	.03
6665	4	0	.29	.01	9.06	.09	40	5	.24	1.08	.07	7755	6	13.81	.02
7072	6	1	.34	.02	9.12	.09	57	6	.32	0.85	.07	8261 :	5	12.96	.04
7482	9	2	.39	.02	9.23	.07	48	14	.29	0.68	.07	8717	7	13.83	.04
7863	9	3	.37	.02	9.43	.09	42	16	.37	0.81	.11				
8218	13	4	.28	.03	9.32	.10	43	9	.41	0.69	.11				
8615	5	5	.30	.01	9.91	.07	47	24	.34	0.96	.08				

(RP) described by Andronov (1990) with a filter half–width Δt depending on the mean cycle length. Moreover, we tried a new method of "running sines" (RS). For each trial time t_0 the one–frequency least squares fit is computed by taking into account only the data in the interval $[t_0 - \Delta t, t_0 + \Delta t]$:

$$m(t, t_0) = a_0(t_0) - \sum_{k=1}^{j} r_k(t_0) \cos(2\pi f_k(t - t_0)) \quad (3)$$

The smoothing function is $m(t_0, t_0)$. In this paper we used the filter half–width $\Delta t = P/2$ and $j = 1$.

UV Aurigae

Observations range between 7.5^m to 11.5^m with one estimate 6.4^m at JD 2448127.6 removed which is possibly a misprint. In this system one of the stars is pulsating. Comparison of the data with the one–frequency fit (Fig. 1,2) shows significant cycle–to–cycle changes of the shape. Individual intervals between successive maxima (Tab. 1) are highly variable from 331^d to 430^d. However, the phase changes computed according to the best fit ephemeris are relatively small from –0.08 to +0.08. Here we have not taken into account the last not sure maximum for which the error estimates are large. For comparison of different methods we list in Tab. 1,2 also the characteristics of maxima and minima obtained by the RP method. The RS fit is more smooth, making the shape more sinusoidal. The RP one better fits sharp parts of the light curve.

Periodogram for $O - C$ shows 3 peaks which are formally significant. This is an effect of long–term changes of the phase curve. Significant changes of the mean brightness $a_0(t_0)$ may be noted. The values corresponding to the moments $m(t_0, t_0) = a_0(t_0)$ are listed in Table 3 separately for ascending and descending branches. The range of the brightness variations at "half branch" is from 9.05^m to 10.40^m.

The best fit period 389^d is in agreement with the values obtained for photographic data obtained prior to the AFOEV observations ($P = 377.9 \pm 5.6^d$, $j = 1$, $P = 399.0 \pm 1.7^d$, $j = 4$ (Chinarova 1995) and for recent photoelectric B measurements ($P = 396^d$, Luthardt (1992)). However, the amplitude of the visual observations is much larger than that of pg ($\approx 0.8^m$) or B ($\approx 0.5^m$).

TX Canum Venaticorum

Photometric behaviour of this relatively bright object BD+37°2318 in 1890–1952 yrs was studied by Mumford (1966) who published 9 comparison stars. The periodogram shows highest peak at $P = 3779 \pm 73^d$.

The best fit period for $O - C$ is $P = 474.5 \pm 3.9^d$. The two–frequency model parameters are $a_0 = 9.68 \pm 0.05^m$, semiamplitudes $r_1 = 0.215 \pm 0.007^m$ ($P_1 = 3768 \pm 74^d$, $T_{M1} = 2446988 \pm 21$) and $r_2 = 0.056 \pm 0.007^m$ ($P_2 = 475.3 \pm 3.9^d$, $T_{M2} = 2446887 \pm 10$).

First period corresponds to the "9–yr cycle" mentioned by Skopal et al. (1992), whereas the second one differs significantly from our three "candidates", possibly arguing for a period change. Photographic data by Chinarova (1995) cover the time interval studied by Skopal et al. (1992), but show smaller amplitude $\approx 0.2^m$ (pg) of the "long wave" as compared with $\approx 0.4^m$ (vis).

One may note that there was a luminosity excess of the star prior to JD 24444200 as one may see from the sine and running parabola fits at Fig.2. Thus we have also computed a periodogram for $(O - C)_{RP}$ corresponding to the RP fit with $\Delta t = 1000^d$. The peaks are much lower than at two other periodograms, the highest of which corresponds to $P = 465 \pm 5^d$ and $r = 0.036 \pm .007^m$.

The periodogram computed for our observations on 42 compact distributed in time SAI plates obtained from JD 2445850 to 2447680 shows a complex structure. Three peaks with a nearly equal significance level correspond to periods 282.9 ± 2.9^d ($j = 2$), 352.2 ± 3.0^d ($j = 3$) and 426.5 ± 4.2^d ($j = 4$). These 3 peaks with lower height are present also for $j = 1$. From the whole data set we have chosen 959 AFOEV points in the same time interval and computed a periodogram for $(O - C)_{RP}$. There are few peaks of similar height, one of them corresponding to $P = 485 \pm 10^d$ and $r = 0.043 \pm .008^m$.

Individual cycle lengths obtained from the

RP fit vary from 351^d to 493^d with a mean 360^d. The amplitudes vary from 0.04^m to 0.36^m with a mean 0.15^m. This also argues for cyclic or semi–regular waves rather than for periodic variations.

V 1329 Cygni

Results of the previous studies of the object were published by e.g. Arkhipova (1987). Skopal et al. (1992) presented a part of the AFOEV light curve and 28 pg observations.

Our analysis of the AFOEV data show significant deviations from the sine fit. The characteristics of the extrema derived from the RP fit are listed in Table 3. Individual cycles are characterized by lengths ranging from 772^d to 1084^d with a mean 958.3^d in excellent agreement with the value from the sine fit. The amplitudes range from 0.84 to 1.33^m with a mean 1.13^m. An outburst–like event at JD 2446190 leads to amplitude increase up to an unusually large value 1.87^m. One may note mild extrema marked by semicolon in Table 3 which are owed to relatively small value of $\Delta t = 160^d$ adopted. However, larger values of Δt lead to worth approximation of the brightening.

The brightness estimates on 165 SAI plates (Chinarova 1995) showed two brightness minima near JD 2443871 (14.34^m) and 2444900 (14.47^m) corresponding to a period $P \approx 1030^d$. A maximum between them occurred near JD 2444427 (13.29^d). Significant difference of the brightness at minima caused apparent deviation of the best fit value $P = 966 \pm 15$ corresponding $j = 2$. These data fill the gap in the AFOEV observations.

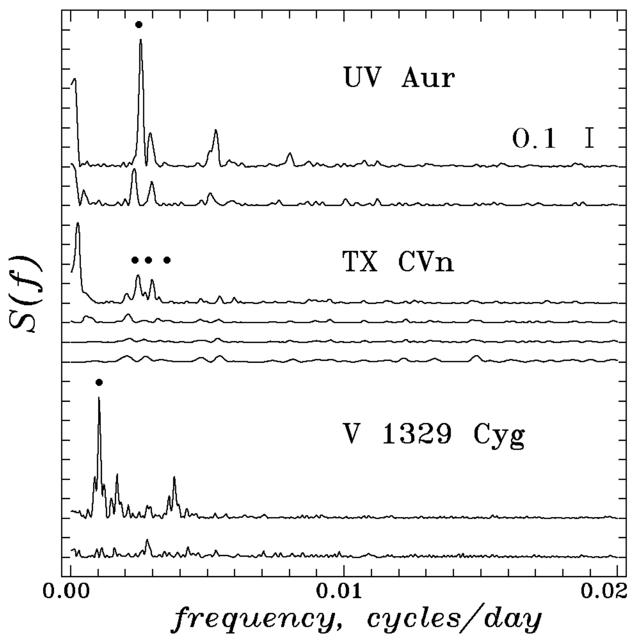


Figure 3. One–frequency periodograms for the original (C) observations (up), residuals from the best sinusoidal fit ($O-C$) (lower). For TX CVn are additionally shown the periodograms for deviations from the RP fit $(O-C)_{RP}$ for all data (5^{th} curve) and for the shorter time interval coinciding with that covered by our photographic study (6^{th} curve). Filled circles mark best fit periods (3 candidates for TX CVn) corresponding to photographic observations of Chinarova (1995).

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ESTIMATING SPATIAL DENSITY OF CLOSE BINARY SYSTEMS WITH SUBGIANT SECONDARIES IN SOLAR NEIGHBORHOOD

O. V. Eretnova
Department of Physics, Chelyabinsk State University
ul. Br.Kashirinikh, 129, Chelyabinsk 454136 Russia
E-mail: nig@cgu.chel.su

ABSTRACT. The spatial density of close binary systems with subgiant secondaries in solar neighborhood are evaluated taking into account the effects of observational selection. It was found to be about 0.00018 pc^{-3} or about 0.00035 $M_\odot$ pc^{-3}.

Key words: Close binary systems, Effects of observational selection, Spatial density.

In close binary systems (CBS) with subgiant secondaries the more massive components are the stars of Main Sequence (MS) and the less massive components are the subgiants with considerable excesses of luminosity and radius. Among the known eclipsing variable stars 50 per cent are the systems with subgiant secondaries. However observational data are too distorted by observational selection effects and do not show the real number of these systems in space.

In this paper the effects of observational selection connected with both discovery probability of CBS as eclipsing variable stars (Eretnova & Svechnikov 1991) and incomplete investigation samples (Eretnova & Svechnikov 1993) were taken into account to estimate the spatial density of these systems. The information about 2240 systems with subgiant secondaries from the "Catalogue of approximate photometric and absolute elements of eclipsing variable stars" by Svechnikov & Kuznetsova (1990) was used as observational data.

The evaluated spatial density of research systems approximately was found to be 0.00018 pc^{-3} or about 0.00035 $M_\odot$ pc^{-3}. It is about 1% from the total density of star mass in 1 cubic parsec which approximately is 0.0044 $M_\odot$ pc^{-3} according to Allen (1977). However the systems of K– and M– spectral classes were not encountered among the CBS with subgiant secondaries. The spatial density of these systems in other spectral classes is about 4% from the total star mass density in 1 cubic parsec which equals to about 0.0089 $M_\odot$ pc^{-3} in the same spectral classes.

The comparison of estimated space density with corresponding data to CBS where both components belong to MS is of certain interest. Among the eclipsing variable stars the CBS with subgiant secondaries are about 6 times as numerous as the main – sequence binaries. According to Svechnikov & Kuznetsova (1992), the real number of CBS with both components belonging to MS in 1 cubic parsec is about 0.00066 pc^{-3}. Thus the spatial density of main – sequence binaries on the early evolutionary stages exceeds the one for CBS with subgiant secondaries approximately by 3.5 times. It agrees with computational data.

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ESTIMATE OF MASS LOSS RATE FROM ALGOL – TYPE SYSTEMS BASED ON RADIOFLUXES

L. V. Glazunova[1], I. B. Pustylnik[2]
[1] Astronomical Observatory, Odessa State University, T.G.Shevchenko Park, Odessa 270014 Ukraine
[2] Institute of Astrophysics and Atmospheric Physics, Estonian Academy of Sciences Tartu, Tõravere EE2444 Estonia

ABSTRACT. The estimates of the upper limit mass loss rate from Algol–type binaries based on observations at radio wavelengths match well the results obtained from the optical data. This mass loss rate suggests that Algol–type systems observed at radio wave lengths have optically thick core, the sizes of the latter are larger than the size of the system. Due to this fact all the Algol–type binaries are weak single radio sources.

Key words: Stars: Algol–type binaries, radioemission, mass loss rate.

Observational data on Algol–type and related binary systems in radio frequencies are still scattered and scarce. Algols are relatively weak radiosources, especially in comparison with RS CVn type systems, where large radio data sets have been sampled. The only exception is Algol itself for which sufficiently long time series have been obtained (Woodwoorts & Hughes 1976). Radioflux from Algol in cm wave–length band ranges between 50 mJy and several Jy. Rapid temporal flux fluctuations, high brightness temperature ($T_e = 10^7$K) and drastic changes of spectral index are suggestive of non–thermal mechanism of emission. Two component models with both thermal and synchrotron components provide an adequate interpretation of radio data for a wide range of stars of different spectral and luminosity classes, both single and double ones. Such a model was successfully employed by (Woodworth & Hughes 1976) to Algol, who associated variable flare component with synchrotron mechanism, whereas radioflux of 50 mJy in a quiescent state apparently is due to thermal emission. Analysis of thermal component enabled them to evaluate the size of the envelope surrounding Algol, gas temperature and the mean density.

Recently Umana et al. (1991) published VLA data for 14 Algol type binaries at 5 GHz. We have used these data to assess the upper limit of the mass loss from these systems to get a better insight in their evolutionary status. The systems under investigation and their basic parameters are presented in the Table 1. Notations used in Table 1 are self–explanatory. Mass loss estimates from Algol – type systems are based exclusively on the optical data and are uncertain ranging between 10^{-10} $M_\odot$/yr and 10^{-8} $M_\odot$/yr. Thus even upper limits based on radiofluxes will usefully complement earlier evaluations. We assume that: i) envelope surrounding the system is spherically symmetrical, fully ionized, T_e=const; ii) density–scales as $r^{-\eta}$. In the frame–work of our model density flux in radio range can be determined using equation:

$$S = \frac{2\pi B}{D^2}\left[\int_0^{r_1} x \ (1-\exp(-\tau_1(x)))\ dx \ + \right. \left. + \int_{r_1}^{r_2} x\ (1-\exp(-\tau_2(x)))\ dx \ + \ \frac{r_1^2}{2}\right], \quad (1)$$

where B is Planck function, D is the distance from the object, r_1 is the radius of an opaque core; r_2 is on appropriately chosen radius of the envelope. The first and the second terms describe the contribution from a semi–transparent

Table 1.

N	Systems	Sp	A($R_\odot$)	D(ps)	S(mJY)	σ	M($M_\odot$/year)
1	YZ Cas	A2 + F2V	17.6	107	0.25	0.09	$2.75 \cdot 10^{-9}$
2	RZ Cas	A3V+ K0IV	6.3	75	3.25	0.05	$1.10 \cdot 10^{-8}$
					1.25		
3	AS Eri	A2V+ G9IV	10.4	200	0.09	0.03	$3.27 \cdot 10^{-9}$
4	RZ Eri	A5e + G8	73.5	143	0.97	0.06	$3.42 \cdot 10^{-9}$
					2.31		$2.30 \cdot 10^{-8}$
5	R CMa	F0V+ K1IV	5.4	42	0.36	0.10	$8.90 \cdot 10^{-10}$
6	TT Hya	A2Ve+K1.5IV	21.7	193	0.06	0.02	$2.32 \cdot 10^{-9}$
7	δ Lib	A0V + F8IV	12.0	100	0.48	0.16	$4.21 \cdot 10^{-9}$
8	α CrB	A0V + G9	42.1	25	0.63	0.11	$1.99 \cdot 10^{-8}$
9	TW Dra	A6V +G5	11.4	190	3.90	0.05	$5.11 \cdot 10^{-8}$
					0.30		$2.50 \cdot 10^{-9}$
10	AI Dra	A0V + G4IV	7.1	182	0.09	0.03	$2.84 \cdot 10^{-9}$
11	RY Aqr	A3 + G9IV	7.7	180	0.22	0.06	$5.43 \cdot 10^{-9}$
12	V 505 Sgr	A1V + F9IV	7.0	120	3.05	0.06	$2.13 \cdot 10^{-8}$
13	DL Vir	A4V + K0IV	7.1	128	0.17	0.06	$2.69 \cdot 10^{-9}$
14	β Per*	A0V + KIII	14.0	25	50.0	0.05	$1.65 \cdot 10^{-8}$

Remark: * - Woodwoorth & Hughes (1976)

envelope. The third term denotes the contribution from the optically thick core with $r = r_1$. The optical depths along the line of sight are as follows:

$$\tau_1(x) = \int_{\sqrt{r_1^2-x^2}}^{\sqrt{r_2^2-x^2}} \kappa_\nu \, n_1^2 \left(\frac{r_1^2}{x^2+s^2}\right)^\eta ds, \qquad (2)$$

$$\tau_2(x) = \int_0^{\sqrt{r_2^2-x^2}} \kappa_\nu \, n_1^2 \left(\frac{r_1^2}{x^2+s^2}\right)^\eta ds$$

where n_1 is the number density of gas at r_1, κ_ν – absorption coefficient per atom. r_1 and r_2 have been evaluated using subsequent formula (for more details see Paragia & Marcello 1975):

$$r_1 = \left(\frac{\pi n_0^2 \kappa_\nu r_0}{2\,\tau_c}\right)^{1/3},$$

$$r_2 = 10.984\ 10^{15} \left[\frac{n_0\, r_0^2}{10^{36} sm}\right]^{2/3} \left[\frac{\nu}{10GHz}\right]^{-0.7} \left[\frac{T_e}{10^4 K}\right]^{-0.45} \qquad (3)$$

There r_0 is the average radius of a component filling in its critical Roche lobe, n_0 is the density at $r = r_0$, τ_c – the optical depth at $r = r_1$ is a free parameter. $\dot{M} = 4\pi\ r_0^2\ n_0\ v_{exp}\ \mu m_H$, where v_{exp} is the velocity of expansion. The numerical constant in expression for r_2 differs from the value given in (Paragia & Marcello 1975) since we define r_2 as corresponding to the line of sight optical depth equal to $\tau = 0.05$. Thus, free parameters of our model are T_e, η, r_0, v_{exp}, τ_c ($T_e = 10^4 - -10^5 K$, η=1.5, 2.0, 2.5; v_{exp} =100, 500 km/s,τ_c=3). For a set of free parameters we adopted the initial value $\dot{M}(n_0)$, calculated r_1 and r_2, then using formulae (2) – τ_1 and τ_2, the flux density S_T with the aid of Eq.(1). S_T has been compared with the observed S_H and as long as $S_T \le S_H$, n_0 has been increased and the whole computational scheme has been repeated. Results of computations indicate that r_1 in all cases studied so far exceeds the size of the orbit. Thus duplicity of the objects has n_0 influence upon radioflux. The values of r_1 and r_2 for models with η=2, are approximately in 1.6 times higher, than for models with η=1.5 and in 1.25 time less than for models with η=2.5. r_1 with the creasing T_e decrease faster than r_2. n_0 for models with η=2.0 in two times higher, than for models with η=1.5 and in 1.4 time less, than for models with η=2.5. n_0 decrease with grow of temperature faster for η=1.5, than for η=2.0, 2.5. Models for v_{exp}=500 km/s differ from models with v_{exp} = 100 km/s, approximately by 4%. Models with different meanings are also different on 4%. In the Table 1 for models with $T_e=10^4$K, η=2.0, v_{exp}=100 km/s and τ_c =3 mass loss rates $\dot{M}$ are presented for components of investigated systems, filling in their Roche lobe. We can see that $\dot{M}$ matches the values obtained from the optical data. This circumstance explains why all Algol-type binaries have been observed as weak single radiosources.

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SPECTRAL AND PHOTOMETRIC INVESTIGATION OF THE NEW POLAR RE 1149+28

J. M. Bonnet-Bidaud [1], M. Mouchet [2], T. A. Somova [3], N. N. Somov [3]
[1] Service d'Astrophysique, DAPNIA/SAp, F-91191, Gif sur Ivette Cedex France
[2] Meudon Observatory, 92290 Meudon, France
[3] Special Astrophysycal Observatory, Nizhnij Arkhiz, 357147, Russia

ABSTRACT. Spectral and photometric observations of the new polar RE 1149+28 at the 6-m telescope of the Special Astrophysical Observatory of RAS were carried out on 1993 February 14th. The spectra were obtained with a the TV scanner (Drabek et al. 1986) mounted on the spectrograph SP-124 at the secondary focus (N1) in the wavelength range (3950-4950 Å) with the spectral resolution 2Å. Photometric UBVR measurements and light curves in filter B, using NEF photometer (Vikuliev et al. 1991), were also performed . The brightness of the source in filter V was 17.20 ± 0.01 magnitude. The behaviour of the hydrogen and helium emission lines profiles (H_β, $H\gamma$, He II 4686), equivalent widths, relative intensities, halfwidths and velocities, was investigated. Analysis of the velocity curves of the emission lines gives a mean period of (90.00 ± 0.5) min. This is the first precise determination of the orbital period of the system, allowing a definitive choice between the two possible periods suggested from ROSAT X-ray observations (90 and 103 min) (Mittaz et al. 1992).

Key words: Stars: Cataclysmic: Polars

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MASS TRANSFER IN ECLIPSING BINARY STARS

V. G. Karetnikov, E. V. Menchenkova, V. V. Nazarenko
Astronomical Observatory, Odessa State University,
T.G.Shevchenko Park, Odessa 270014 Ukraine
E-mail: root@astro.odessa.ua

ABSTRACT. Analysis of the properties of the eclipsing binary stars shows, that the stream–like mechanism of the mass transfer switches on at a contact evolutionary stage, preceding to a stage of binaries with a subgiant. The computations of the gas streams near the inner Lagrangian point have been made for the intermediate–mass contact systems of the early spectral classes ($CE-$ systems). The properties of the streams are discussed and the conclusions are done concerning the evolutionary stage of the stars of this type.

Key words: Stars: binaries: close, eclipsing; circumstellar matter.

Mass transfer in eclipsing binary systems exists since their origin and continues as a stellar (for all stellar masses) and magnetic (for stellar masses $\leq 1.5M_{\odot}$) winds. However at some evolutionary stages of close binary stars the stream mechanism becomes more efficient as compared with the wind. This stream–like mass transfer via vicinities of the Lagrangian points (at first of the point L_1), under certain conditions, shows a largest mass transfer. Clarification of such conditions is the aim of the present work.

Investigation of the properties of the eclipsing binary stars of various types shows that a stream–like mechanism of the mass transfer is not observed in MS–systems, but is present in $SD-$ and $DS-$ systems which contain a subgiant star. Mass streams are well observed in contact early $CE-$systems and are possibly present in $CW-$type stellar systems. While locating the mentioned above types of systems according to their evolutionary stage (Karetnikov 1987, 1991) one may say that the stream–like mechanism of mass transfer arises at a contact stage of evolution, when the systems consist of stars having properties close to that of the main sequence stars.

Contact stage is characteristic for $CW-$ and $CE-$ systems. In the average, the degree of filling the Roche Lobe is $R1A = 1.03$ for more massive star and $R2A = 1.03$ for the secondary both for $CW-$ and $CE-$ systems. According to Karetnikov (1990), progenitors of the contact $CW-$ systems are low–mass ($M \leq 1.5M_{\odot}$) stars from the $MS-$ systems which have orbital periods less than 4 days. Later on, due to the angular momentum loss via magnetic stellar wind, they must shrink after $\approx 4 \cdot 10^6$yrs into single star, if there are no mechanisms preventing such a process. $CW-$systems exhibit circumstellar gaseous components. However, no clear evidence for the gaseous streams was detected besides Dumitrescu (1974).

In contact $CE-$systems the gaseous streams are well observed and play a significant role in their evolution. Optically thick gaseous disks and gaseous envelopes with a complex structure existing in these systems may arise and be fed only by a strong stream–like mechanism of the mass transfer. They show largest among eclipsing systems mass loss rates and degrees of overfilling (up to 20 per cent) their Roche lobes (Karetnikov 1987; Wilson & Rafert 1981). Al these circumstances make necessary the creation of the gaseous streams in the contact early stars.

Let's study probable properties of the mass streams in the $CE-$systems near L1 assuming that : a) mass–losing star overfills its Roche Lobe and the point L1 lies deep inside its atmosphere; b) stars of the contact pair have properties corresponding to the Main Sequence.

Table 1. Main parameters of the investigated systems.

Star	P(d)	$M_1/M_\odot$	$M_2/M_\odot$	$A/R_\odot$	$R_1/R_\odot$	$R_2/R_\odot$	Reference
β Lyr	12.914	2.0	11.7	55.0	12	25:	Ziolkowski (1976)
V367 Cyg	18.598	2.3	3.6	53.0	18	21:	Menchenkova (1990)
RY Sct	11.125	10	33	75	21	36:	Antokhina & Cherepashchuk (1988)

Table 2. Stream parameters in the vicinity of the point L1.

Star	Xo	XL	NL(cm^{-3})	TL(K)	VL(km/s)	Rs	M($M_\odot$/yr)
β Lyr	0.38	0.32	$6.4 \cdot 10^{14}$	46000	29.5	0.15	$6.4 \cdot 10^{-6}$
V367 Cyg	0.54	0.45	$5.2 \cdot 10^{14}$	51800	28.5	0.19	$1.8 \cdot 10^{-5}$
RY Sct	0.40	0.39	$1.4 \cdot 10^{15}$	69100	32.3	0.15	$1.0 \cdot 10^{-5}$

By using these assumptions, the properties of the gaseous streams near L1 were computed for 3 contact early objects β Lyr, V 367 Cyg and RY Sct (Karetnikov et al., 1994). The computations were made by using an algorithm proposed by (Nazarenko 1993) and are based on the application of the Kurucz's (1979) model atmospheres.

The absolute characteristics were published by Żiolkowski (1976), Menchenkova (1990), Antokhina & Cherepashchuk (1988) and were used for computations. Initial conditions were obtained from the observed concentration of matter near the first Lagrangian point (NL), which allowed to determine co-ordinates of the initial shell X_0, location of the point L1 (XL), environment temperature TL, speed of motion VL and of sound VL, and radius of the stream Rs corresponding to the decrease of the density by a factor of $\approx 10^3$. The origin of co-ordinates is in the center of the mass-losing star, the abscissa coincides with the line of centers and the ordinate lies in the orbital plane. Separation between the centers of stars a is used as a unit distance.

The analysis of the computations has lead to the following conclusions:

1. Observed gas streams in the systems studied arise due to the overfilling the Roche Lobe by the star and needs no other conditions. The overfilling is really observed and may be resulted by a fast variation of the stellar radius during the $B-$çase evolution.

2. Gas stream near L1 moves along the line of centers towards the more massive stars. It is axially symmetrical with a density maximum near the axis and a density decrease to the borders according to a complex law. Behaviour of the stream far from L1 was not yet computed.

3. Speed of the stream near the axis is $\approx 20 - 30$ km/s and is close to the speed of sound in this gas. In the orthogonal direction the expansion speed is not large (despite observed) and is of few hundred m/s.

4. Dimensions of the gaseous stream are only two times smaller than that of the mass-losing star and is compared with dimensions of the second star in a pair. It is not a thin stream, but a wide flow which can envelop the mass-gaining star.

5. Mass flux via vicinity of the inner Lagrangian point in the systems studied is high – $10^{-6} M_\odot$ for β Lyr and $10^{-5} M_\odot$ for V367 Cyg and RY Sct. It may be noted that two last stars show more strong and complex circumstellar gaseous features.

By taking into account the small probability of observations of the fast processes of the maximal mass transfer rate, especially in case B, which lasts $\approx 10^2 - 10^5$yrs (Sybesma 1986), one may conclude that during such stages the stream dimensions are larger than the radius of the mass-gaining star. Such stream carries tremendous masses of matter and transfers an initially more massive star into a mass-losing secondary. A process of the 'role exchange' occurs. However, only further slow mass flow takes away a remaining part of an envelope and transfers a star into a subgiant and a system into $SD-$type binary.

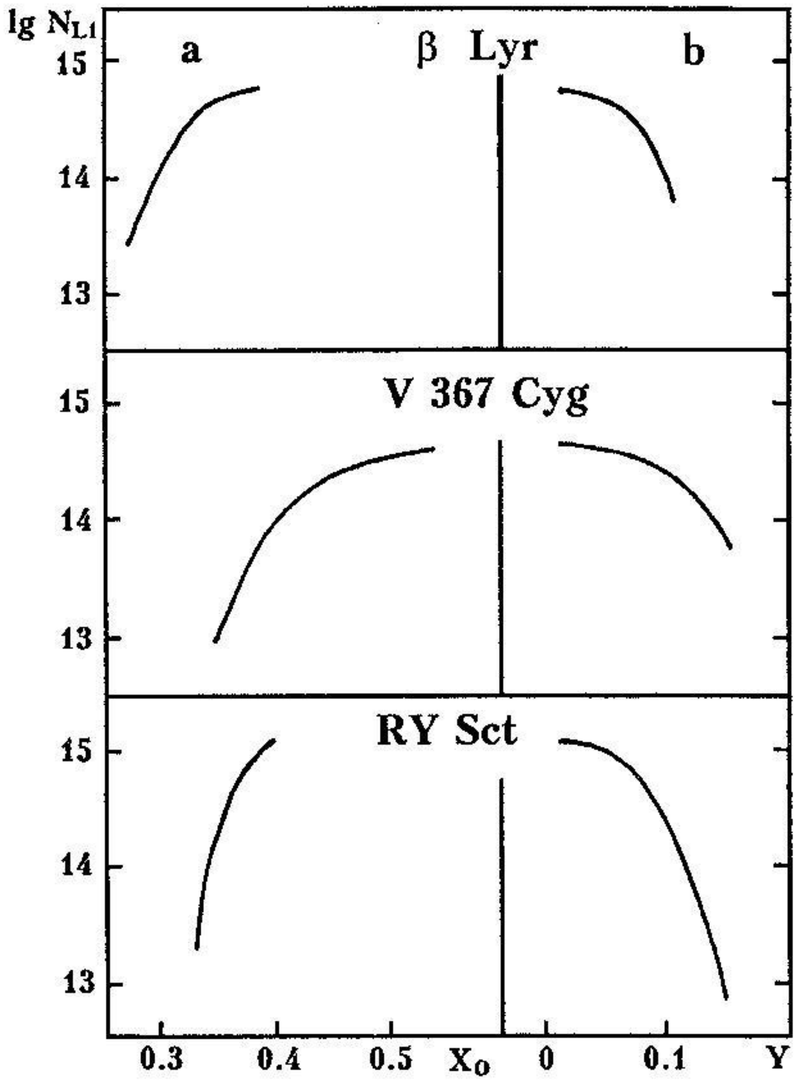

Figure 1. *a* – Dependence of the concentration of matter N_{L1} at the point L1 on parameter Xo, *b* – Distribution of the concentration of matter in the stream along the Y–axis near the point L1.

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DETERMINATION OF THE SPECTRAL TYPE AND LUMINOSITY OF THE HOT COMPONENT OF THE ECLIPSING BINARY STAR RZ ERI

V. G. Karetnikov, E. V. Menchenkova, O. I. Syrov
Astronomical Observatory, Odessa State University,
T.G.Shevchenko Park, Odessa 270014 Ukraine
E-mail: root@astro.odessa.ua

ABSTRACT. By using the spectra taken at 6m telescope and the methods of two-dimensional spectral classification, the non-ordinarity of the main star in RZ Eri is shown. The presence of the circumstellar gas and of the surface activity of the stars in a binary are suggested.

Key words: Stars: Eclipsing Binaries; Spectral Type; Spectral Criterion; Model Atmospheres.

According to Svechnikov's (1986) classification, the eclipsing binary star RZ Eri belongs to the class of DS-systems. These close binaries contain a subgiant secondary which does not fill its Roche lobe. RZ Eri is also a member of the group of the RS CVn-type stars which show emission lines H and K Ca II, presence of star spots and a solar-type activity of the surface layers. This object was studied many times photometrically and spectroscopically and shows a wide variety of short- and long-term instabilities.

Main absolute characteristics of stellar components and the system as a whole were determined by Burki et al. (1992) and Popper (1988). They are summarized in Table 1. Photometrically the system is characterized by a well pronounced reflection effect causing periodical brightness variation; by a well determined rotational period of the stars in a pair; by a long-period 1600^d oscillation of the nonstationary brightness variation. Secondary minimum in RZ Eri is shallow and is centered near phase 0.67. At the center of primary eclipse a brightness excess is observed which we explain by a light refraction phenomenon arising in the atmosphere of the eclpsing star.

Earlier Cesco & Sahade (1945) and Gadomski (1957) detected circumstellar matter. According to Burki et al. (1992), the color excess $E_{B-V} = 0.17^m$ describes light absorption in a circumstellar envelope with $A_V = 0.56^m$ and radius $r = 1800$ A.U. Properties of matter in this envelope and of the intelstellar matter are equal (Murray et al. 1990), what is also justified by a presense of the IR excess (Busso et al. 1990). There are circumstellar gaseous structures in this system which carry matter at a rate $M = 1.7 \cdot 10^{-11}\ M_\odot$/yr. Total mass loss at a subgiant stage is estimated as $2 \cdot 10^{-4}\ M_\odot$.

Separate interest is attracted to determination of the spectral type of the stellar components of RZ Eri. First estimates of Cesco & Sahade (1945) gave a spectral type *A5m* for a primary, what was doubted. Later Popper (1988) estimated types as F5 V + K2 III-K2 V. Recently Burki et al. (1992) estimated spectral types as A8-F0 IV for a hot star and G8-K2 IV-III for a cold one. Temperatures of stars correspond to $\lg T_{eff,1} = 3.869$ and $\lg T_{eff,2} = 3.68$, for gravitational acceleration $\lg g = 3.75$ and 2.97, respectively. Divergence of results is seen which obtained by using different methods. Thus we decided to redetermine spectral types of stars based on our data.

The work was based on two difractional spectrograms of RZ Eri obtained on 28.08.1991 at the 6-m telescope of the Special Astrophysical Observatory of the Russian Academy of Sciences with dispersions 9 and 28 Å/mm at phases 0.31 and 0.34. Spectrograms in intensities were digitized by an automatic photometer of the Crimean Astrophysical Observatory and redu-

Table 1. Parameters of the binary RZ Eri.

$P_0 = 39.28254^d$	$M_1 = 1.69\ M_\odot$
$T_0 = 2446048.883$	$R_1 = 2.79\ R_\odot$
$e = 0.377$	$M_{bol,1} = 1.40^m$
$\omega = -47.3^o$	Sp_1 = A8–F0 IV
$i = 89.30^o$	$P_{rot,1} = 2.4^d$
$A_V = 0.65^m$	$M_2 = 1.63\ M_\odot$
$r = 180$ pc	$R_2 = 6.80\ R_\odot$
$r_{env} = 1800$ A.U.	$M_{bol,2} = 1.45^m$
$t = 3.3 \cdot 10^9$ yr	Sp_2 = G8–K2 IV-III
$A = 72.52\ R_\odot$	$P_{rot,2} = 34.5^d$

ced by using the "SPE" computer code elaborated by S.G.Sergeyev. By using the tables of Griffin (1979) and Moore et al. (1966) the spectral lines were recongized. Their characteristics were determined by fitting the lines by a Gauss approximation.

For determination of the spectral type of the hotter star we used the method of two-dimensional spectral classification of Kopylov (1960). Results are presented in Table 2. Dispersion of estimated values is large within interval from A 5.3 – F 2.7. Mean value Sp_1=A9±3.

Determination of the spectral type of the primary star in RZ Eri was also made by using the method of model atmospheres. The shapes of the lines $H\beta$, $H\gamma$ and $H\delta$ were reduced by using the "Balmer" computer code. For effective temperature and gravitational acceleration we had obtained $\lg T_{eff,1} = 3.804 \pm 0.006$, $\lg g_1 = 4.4 \pm 0.3$. It may be noted that this temperature is by $\approx$ 1000 K lower than estimates made by other authors (cf. $\lg T_{ef,1} = 3.869 \pm 0.006$ in Burki et al. (1992)) and corresponds to a spectral type ≈F7 and a luminosity class ≈V.

From the characteristics of the hydrogen spectral lines the electron number density in the primary's atmosphere was estimated. By using the method of Unsold (1941) we obtained the following estimates: $\lg n_e(H\beta) = 14.09$, $\lg n_e(H\gamma) = 14.28$, $\lg n_e(H\delta) = 14.46$. Mean value $\lg n_e(H) = 14.28 \pm 0.15$. This value corresponds to a spectral type F7 V. Thus modeling the hydrogen lines only gives same spectral type F7 V which is much later than that estimated by Burki et al. (1992).

Analysis of the obtained results argues for a pecularity of the spectral type of RZ Eri.

Table 2. Spectral type estimates of main star in RZ Eri. (Criteria of Kopylov (1960) transliterated from Russian.)

Crit.	type	Crit.	type	Crit.	type
Zh	F 0.2	M	A 5.3	R	A 7.4
Z	F 0.3	N	F 2.2	S	A 7.1
K	A 7.8	O	A 5.8	T	F 0.6
L	F 2.7	P	F 0.5	H	A 7.5

By using criteria of Kopylov (1960), one may say that there are three "simultaneously coexisting" spectral types: A5.6 (2 criteria), A7.4 (4 criteria), F0.6 (4 criteria), and F2.4 (1 criterium) with a scatter ≈ 0.2 within a group. However, models of the hydrogen lines argue surely for F7 V. This characteristic is close to the Popper's (1988) estimate but does not agree with recent results of Burki et al. (1992). It is also distinctly outside the interval of the spectral types obtained from the same data by using other spectral criteria. Possibly we deal with distorsional influence of the circumstellar gas and of the surface activity of stars in the system RZ Eri. Further study is highly needed.

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PHOTOMETRIC OBSERVATIONS OF THE R AQUARII SYSTEM

T. N. Khudyakova
Astronomical Observatory, St.Petersburg University
Bibliotechnaya Pl., 2, Stary Peterhof, St.Petersburg 198904 Russia
E-mail: vayak@astro.lgu.spb.su

ABSTRACT. Photometric BVRIJHK observations of the symbiotic star R Aqr are presented. The data were obtained at Byurakan Station of the St.Petersburg University Astronomical Observatory during the interval 1971–1991, using AFM–6 photometer (C–8 type photocatode) at the 48 cm telescope (BV), the IKAF–1 photometer (S1 type photocatode) at the 48 cm and 62 cm telescopes (RI), IKAF–2 PlS photometer at the 62 cm telescope (JHK). The photometry was made and reduced to Johnson system in the usual manner for broad–band photometry. The main part of the data were obtained in red and near infrared, and my report will concern the cold component.

Key words: R Aqr – long–period variables – symbiotic binaries

The primary [cold] component of the R Aqr system is LPV with a period of 387 days, a spectral type of M3e – M8.5e + pec and amplitude of variations between V(max) of 5.8 mag and V(min) of 12.4 mag (Kholopov et al. 1985). The double star is surrounded by an extended emission nebula with a diameter of outer ring of about 2'. Most of the nebula is concentrated into an inner core about 30" across.

The stellar spectrum shows a variable blue component (a secondary), which presumably is linked with the ionization nebula. The hot component is probably a white dwarf or a subdwarf.

The orbital period of the system is not known exactly. It appears to be greater than 20 years: 27 (Merrill 1950) or 44 years (Wallerstein 1984). This is supported by our polarimetric data as well. The distance to the object is 260 pc, and the interstellar extinction is small E(B–V)=0.03 (Eggen 1970).

The hot component was not photometrically active during the period of the observations. The light curve of R Aqr shows two kinds of the brightness changes: variations of the cold component brightness and much more slow variations of the average brightness. We have separated these changes and obtained the mean light curve for RIJHK bands. Unfortunately, we have not enough data to do that in BV.

We have found the ephemeris for Mira variations:

$$\mathrm{JD}_{min} I = 2442454 + 384.4 \cdot E \qquad (1)$$

In red and near infrared, R Aqr satisfies to all the criteria for normal LPV:

- shape and phase of light curve,
- wavelength dependence of amplitude,
- time of maximum light is progressively
- delayed with increasing wavelength, and
- the star's position in the near infrared two–color diagrams.

The depression of the Mira maximum can be interpreted as a result of the eclipse of the cool component by an extended disk or cloud around secondary (Willson et al. 1981). The total duration of the eclipse is 7–8 cycles of Mira. There appears to be no plateau in the minimum. In visual region the brightness of the star falls down to B=V=13.2 mag which corresponds to the hot sources' (nebula+hot secondary component) intensity level. A loss of light in a central phase of the eclipse is 2.8, 2.8, 2.1, 1.9, 1.6 mag in R, I, J, H, K bands, respectively. The eclipsing object must be a large, non–luminous body. But at present we cannot definitely say what it is.

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BM ORI: SEARCH FOR SECONDARY SPECTRAL LINES

V. S. Shevchenko[1], E. A. Vitrichenko[2]
[1] Astronomical Institute, Tashkent, Uzbekistan
[2] Space Research Institute, Moscow, Russia
E-mail: mnatenzo@esoc1.bitnet

ABSTRACT. The search for the secondary spectral lines was made by using special high signal/noise ratio emulsion A700u. The four spectra (two near elongations and two near conjunctions) were obtained with 6-m telescope (BTA), dispersion is 26 Å/mm. We searched the weak lines and made the next conclusions. The following splitted stellar lines are seen: O II 4699, Mg II 4481, Si IV 4116, N II 5747, N II 5001, N II 5747 and others. The contours of these lines are complex: each have absorption contour, emission core and an Orion nebulae emission line. It made difficult the line recognition. Also are seen the splitted circumstellar lines Na I 5890 and 5896 with the same radial velocities as stellar lines. If that fact is real the next parameters of the system may be derived: $K_1 = 156$ km/s, $K_2 = 232$ km/s, so the mass ratio $M_1/M_2 = 1.5$ and $M_1 = 24$, $M_2 = 15\ M_\odot$; radii of the primary and secondary are 4 and 13 $R_\odot$. The errors may be about 10%. Both stars are of B2 spectral type, both are surrounded by gas/dust envelopes but the secondary has more opaque dust envelope and that produces the reddening about 0.3 optical thickness greater then for the primary. That is the reason of the different minima depth for the different spectral regions. All results are preliminary and are to be confirmed.

Key words: Stars: Binary: Eclipsing.

ON THE BINARY NATURE OF PLEIONE

E. V. Menchenkova[1], R. Luthardt[2]
[1]Astronomical Observatory of the Odessa State University
T.G.Shevchenko Park, Odessa 270014 Ukraine
[2] Sternwarte Sonneberg
Sternwartestr. 32, D–96515 Sonneberg, Federal Republic of Germany

ABSTRACT. From analysis of radial velocity measurements the binary nature of Pleione is discussed. A possible orbital period of about 35 yr was detected.

Key words: Stars: Binaries: Pleione

Pleione (BU Tau, 28 Tau, HD 23862) is one of the best investigated Be stars. It shows significant long term variations in its spectrum. Observations of Pleione over more than 100 years show that the active phases appear periodically: 1887–1904 (Be phase), 1904–1938 (B phase), 1938–1955 (Shell phase), 1955–1972 (Be phase), 1972–1989 (Shell phase), 1989– (Be phase). There are many investigations of the envelope of Pleione. At the same time, the nature of the underlying star have been investigated only very poorly, because of the complicate analysis of the shallow and broad lines observed in the spectrum of the rapid rotating star. Most of time in the spectrum of Pleione a great number of shell lines formed in the envelope of the star have been observed. It makes analysis of the spectrum of Pleione some more complicate problem. In the end of 1980s the shell spectrum of Pleione became considerable weak and the conditions for investigation of the underlying stellar spectrum, determination of the parameters of the stellar atmosphere and search for lines of an assumed companion became much better.

We obtained spectral observations of Pleione with the 6–m telescope of the SAO (Zelenchykskay) on April 5, 1990 and the 2.6–m telescope of the Crimean Astronomical Observatory (Nauchny) on December 10, 1990.

Our observations show, that during 1990

1. The lines of the shell spectrum of Pleione disappeared completely.

2. The spectral type of Pleione was equal to B8.

3. There are variations of the equivalent widths (more than two times) and the profiles of the hydrogen lines (Fig.1). The observed variations cannot be a result of variations of the stellar luminosity, because the photometric variability of Pleione is less than 0.6 mag. This effect may be an evidence that the envelope was more developed in april and the profiles of the hydrogen lines were more distorted.

4. The electron density, obtained for layers with different optical depths in december 1990 was equal to the value typical for main sequence stars with spectral type B8. In april 1990 the electron density in the Pleione atmosphere for layers with $\tau \approx 0.3$ was considerably smaller and corresponds to the value typical for supergiant of spectral type B8. This result can witness both about the change of the physical conditions in the Pleione atmosphere and the variation of the strength of the envelope that leads to a change of the influence of the envelope to the profiles of the hydrogen lines.

5. No lines of the secondary component were discovered.

Detailed analyses of all published radial velocities measurements was carried out separately for hydrogen and for lines of metals. The observational data from the time interval 1938...1990 enable us to search for long term periodical variations of radial velocities. The radial velocities of the H lines show a larger scatter than metal lines. A number of lines show very negative values during the epochs 33000...34000 and 46000...47000. These intervals represent the shell phase of Pleione. Such a scatter also occurs for several metal lines, especially Ca II and Fe I. These data were not used for period search. Two methods for period determination were used:

1. Method of Lafler and Kinman (1965).
2. "Fourier transform" (one–harmonic least squares fit by using the program FOUR by Andronov (1994)).

The search was carried out for period intervals 5000...15000 days (13.7...41 years). The best results were obtained for the metal lines because of the smaller scatter in the data. Both methods yielded almost the same results:

Lafler & Kinman	Fourier analysis
metal lines	
6411^d (17.6 yr)	6580^d (18 yr)
12450^d (34 yr)	12856^d (35yr)
H lines	
6500^d	4670^d
12400^d	11468^d

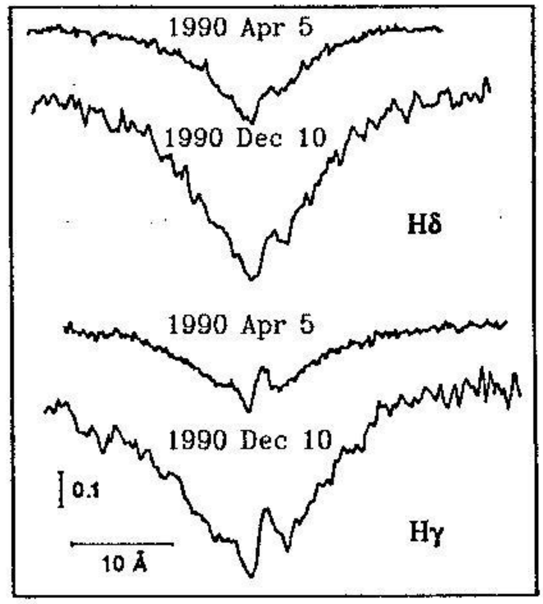

Figure 1: Variations of the profiles of the hydrogen lines $H\gamma$. and $H\delta$ in the spectrum of Pleione in 1990.

The calculated value of the orbital period of Pleione ($\approx$ 35yr) agree well with the variations of the spectral properties of the star (shell – non–shell phase). Our results agree well also with the conclusions published by Gies et al. (1990). In this work time resolved H_α spectroscopy was carried out during an occultation of Pleione by the moon. The observations concluded to an asymmetric envelope which is explained by a companion with $M = 2M_\odot$. During the periastron passage of the companion mass exchange by the primary star increases and a new shell phase begins. The semimajor axis was determined to be $a = 19.1$ A.U., the excentricity $e = 0.46$ and the inclination $0° < i < 43°$.

For an exact determination of the orbital parameters more radial velocity measurements are necessary.

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RHO CASSIOPEAE – GIANT OR SUPERGIANT ?

A. E. Rosenbush
The Main Astronomical Observatory of Academy of Sciences of the Ukraine
Kiev-127, Golosiiv, 252127, Ukraine
E-mail: mars%gao.kiev.ua@ussr.eu.net

ABSTRACT. Variable polarization of ρ Cassiopeae is found, with an amplitude of about 0.2 % in the V band and up to 1 % in R. It is drew attention on a conflict of luminosity from a spectral analysis (about -8 magnitude) and from a trigonometrical parallax (an average from four measurings corresponds to +0.5 magnitude). The paper submitted to *Astronomische Nachrichten.*

Key words: Stars: individual – rho Cas: luminosity–polarization.

LIGHT CURVE VARIATIONS OF THE MAGNETIC CATACLYSMIC BINARY MR SERPENTIS : PHOTOMETRIC PERIOD IS NOT AS SURE AS BELIEVED

E.P. Pavlenko[1], N.A. Ketsaris[2], A.V. Halevin[1], I.L. Andronov[1]
[1] Crimean Astrophysical Observatory, Nauchny, 334413 Ukraine
[2] Sternberg State Astronomical Institute, Moscow, 119899 Russia
[3] Department of Astronomy, Odessa State University, 270014 Ukraine

ABSTRACT. The light curves show very large even for polars night–to–night variability of the amplitudes (from 0.4^m to 1.6^m) and shapes. The flares may be owed not only to the inhomogeneous accretion, but possibly some to the UV–Cet events. Large scatter of the phases does not allow to fit all observations even with one period, arguing for future monitoring.

Key words: Stars: Polars: MR Ser.

MR Ser (=PG 1550+191) was classified as an AM Her–type star by Liebert et al. (1982). Unfortunately, since that time no serious attention was paid to this very interesting object, despite it behaves very exotically.

The observations obtained in 1982–1991 yrs. (Andronov et al., 1992) showed extreme variations of the shape of the light curve similar to that detected in AM Her itself (Andronov et al., 1980). From 6 runs of observations obtained in 1991 in R the following best fit elements were obtained for MR Ser:

$$\text{Min HJD} = 2448446.7284(\pm0.0015) + 0.078795(\pm0.000012)\cdot E.$$

This period's value is close to the spectral one of $0.07879793^d(8)$ by Schwope et al. (1993), but differs from a previously published one 0.0788709^d Szkody 1988) by 7σ. It is not possible to fit all the times obtained in 1981–1991 by the same period. Alltogether 27 minima were collected by Andronov et al. (1992). The phase changes have the large amplitude up to $0.4P$. This phenomenon may arise due to drastic changes in the accretion geometry, despite the cycle number miscount may not be ruled out. The minima systematically occur later at longer wavelengths.

New observations were obtained at the same 50–cm telescope MTM–500 equipped by a TV detector (see Prokof'eva et al. 1993 for description) with time resolution 2.5 min in the instrumental R system (4 runs) and without filter (8 runs). They show a wide variety of types of the light curve variability (Fig. 1,2). The amplitude varied from 0.4^m to 1.6^m. At some light curves the photometric waves were significantly longer than the period. The short– and long (up to 0.25–0.5P) minima were sometimes observed. Many of the curves were distorted by irregular brightenings with an amplitude of $0.2 - 0.6^m$ and timescales from 10 to 30 minutes. Similar to AM Her, the majority of the flares may be explained by accretion events, but few of them (e.g. HJD 2449186.45, 9187.32) resemble in a mild form the unprecedented UV Cet–like flare in the red dwarf in the AM Her system (Shakhovskoy et al. 1993).

Impossibility to fit all the minima by the same period may not be caused only by physical cycle–to–cycle variations of the light curve. Another explanation is secular variation of the photometric period. This means that MR Ser may not be a "true" polar with a magnetic white dwarf *synchronously* rotating with orbital motion, but is at the stage of *"synchronization"* (Andronov 1987) similar to V 1500 Cyg (Schmidt and Stockman 1991; Pavlenko and Pelt 1991) and BY Cam (Mason et al. 1994). However, to test this hypothesis, new regular multicolor observations (or at least in R where they are more pronounced) are needed with a baseline of at least few years.

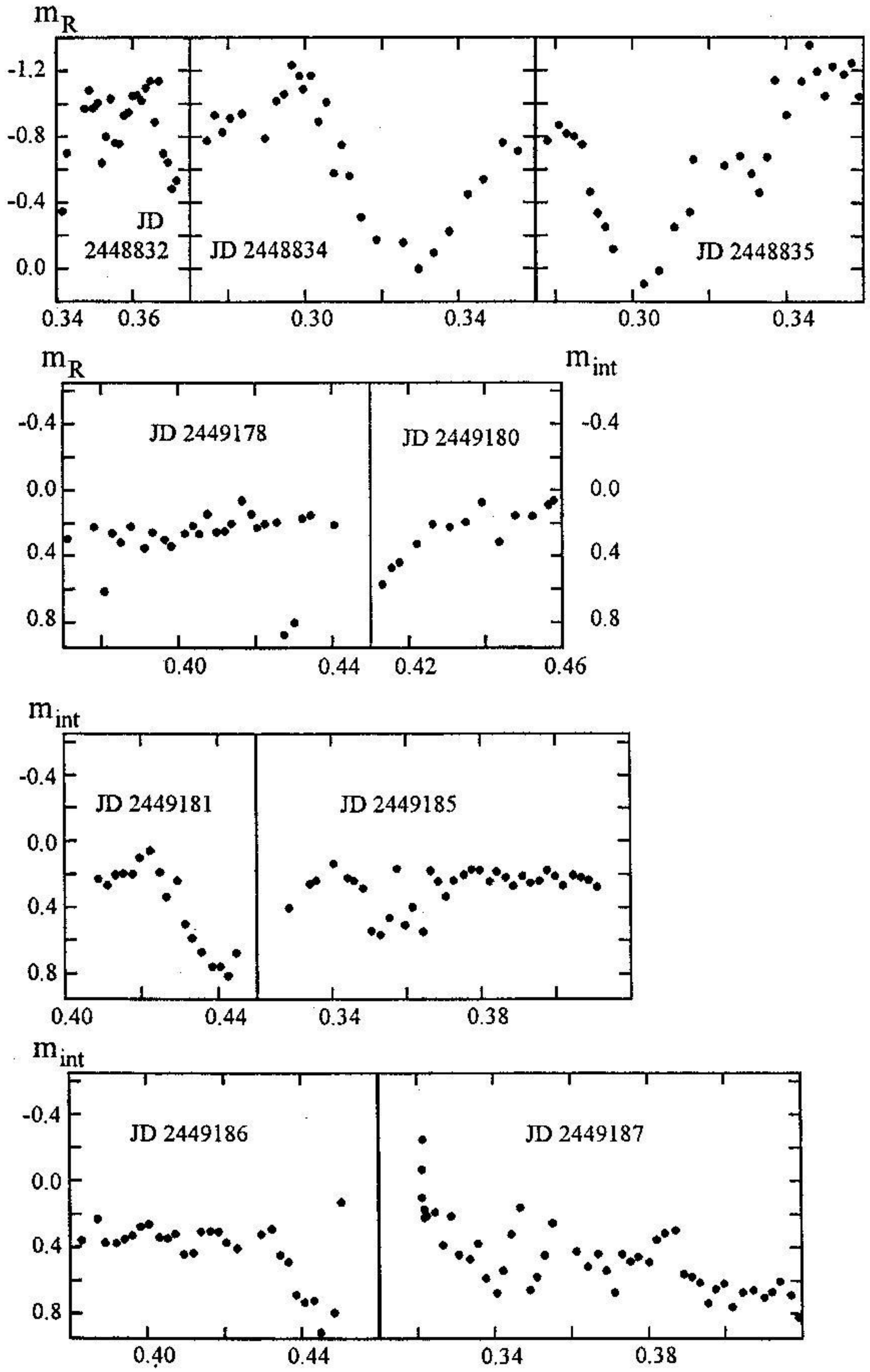
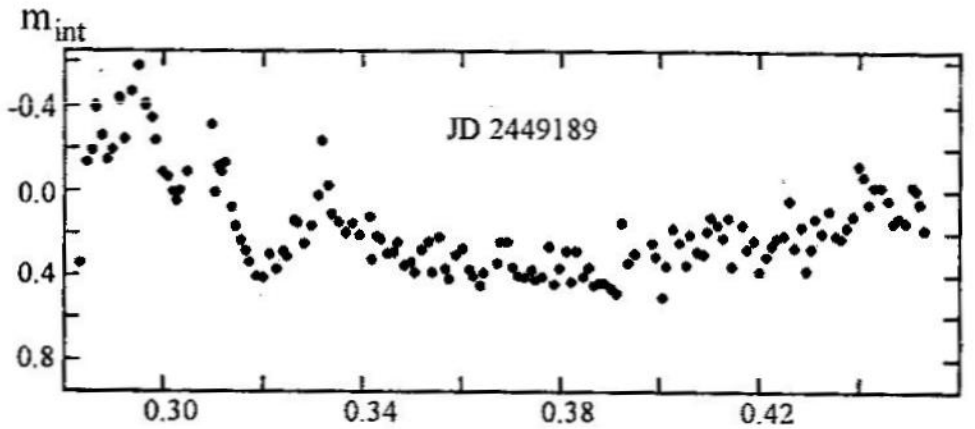
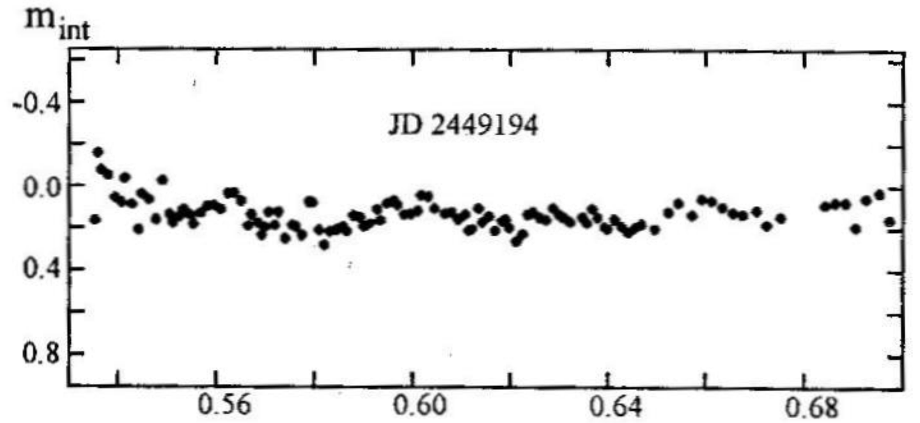


Figure 1. Light curves of MR Ser.





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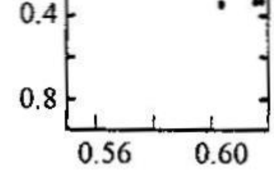

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OUTBURST CYCLICITY OF DWARF NOVA VZ AQUARII

L. I. Shakun
Astrophysical Observatory, Moldova State University
str. Mateevich 60, 277014, Kishinev, Moldova

ABSTRACT. New linear elements for outbursts of VZ Aqr from 1904 to 1987 were obtained with $P_0 = 50.4053^d$. Two states of outburst activity are distinguished with cycle lengths 47.128^d and 55.041^d, replacing each other during $\Pi = 13.2$yr and accompanied by a maximum brightness changes. Instability parameters of VZ Aqr – $\lg P$, $\lg P/P_0$, $\lg \Pi$ and $\lg N_0$ agree well with a dependence of these parameters on $\lg P_0$ derived by the author for other dwarf Novae.

Key words: Stars: Dwarf Novae, Binaries

VZ Aqr, belonging to a Dwarf novae UGSS subtype, was observed in the Astrophysical Observatory of the Moldova State University from JD 2445229 to 46695. At the telescope AZT-3 we have obtained 103 photographic observations.

There were used 49 moments of outbursts, which were determined from the original observations and from literature. The linear elements were determined by using these moments:

$$\text{Max JD} = \underset{\pm 5.244}{2441543.856} + \underset{\pm .0411}{50.4053} \cdot E_0$$

They describe the stellar behaviour during the period 1904 - 1987 yrs. Dependence $(O-C)$ on JD shows that VZ Aqr has two alternating periods of outburst appearance replacing each other. The same outburst cycling resembles the stars of this class which were earlier described by Bianchini (1988) and by Shakun (1987a, 1988). As in the case of UU Aql (Shakun, 1987b), in the behaviour of light at the outburst maximum some peculiarities were observed. Weak outbursts take place in the region of extreme significance $(O-C)_0$.

For linear sections with a sufficient number of observations the corresponding linear elements were calculated, describing the outburst behaviour:

$$\text{Max JD} = \underset{\pm 6.795}{2426169.914} + \underset{\pm .4613}{47.2691} \cdot E_1$$
$$\text{Max JD} = \underset{\pm 5.429}{2440562.293} + \underset{\pm .4451}{54.7552} \cdot E_8$$
$$\text{Max JD} = \underset{\pm 5.109}{2444056.615} + \underset{\pm .3807}{46.9844} \cdot E_9$$
$$\text{Max JD} = \underset{\pm 4.873}{2445516.991} + \underset{\pm .5520}{55.3258} \cdot E_{10}$$

Thus we draw the conclusion that the star has two states of activity with an average periods of 47.128 and 55.041 days appearing outbursts, changing each other with a $\Pi = 4800^d$ cycle.

The star average light at the maximum of the outburst in the first case is equal to 13.3^m, in the second case - to 12.8^m. This means that when the frequency of the outbursts is larger, than they are weaker, as for example, in the case of UU Aql.

The calculated nonstability parameters of the outburst activity of VZ Aqr sufficiently join the earlier determined Shakun's (1989) dependence of the same parameters on $\lg P_0$ for other Dwarf novae.

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RECENT RESULTS TO BETA LYRAE'S NATURE ON THE BASE OF OBSERVATIONS WITH CCD-DETECTOR

M. Yu. Skulskyj
University "Lviv politechnic"
E-mail: msky@astro.lviv.ua

ABSTRACT. The main results of the investigation of composed spectrum of massive interacting binary β Lyrae are reported. They are based on the study of dynamical and energetical parameters of the emission - absorbtion lines Si II 6347, 6371, Hα, He I 6678, 7065. The high resolution and S/N ratio red spectrogramms of β Lyrae system in general are obtained in 1990-1992 with CCD camera, incorporated into 2.6 m telescope of Crimea Astrophysical observatory.

Key words: Stars: Binary; Stars: Mass transfer

First of all, we revealed first confidently in the silicon doublet the absorption lines of the massive faint component (gainer) that reflecting her the orbital motion (Skulskyj & Topilskaya 1991; Skulskyj 1992). Orbital elements of both components ware calculated for the date 1990-1992. The obtained mass ratio q=4.5 can be considered as final one, the mass of the bright losing component (loser) is 3.0 and the gainer is 13.4 solar masses (Skulskyj 1993c). These data characterize the modern evolutionary status of interacting binary system β Lyrae.

In the second place, the creation of the equipment (Stokesmeter + CCD-detector, Plachinda et al., 1993) allowed us to start (Skulskyj and Plachinda, 1993) the detailed study of β Lyrae magnetic field by odservations of single lines Si II 6347, 6371 in 1991-1992 (the discovery of magnetic of losing component (Skulskyj 1985) has jet not analogy and demands serious reserch). The main result are: the independence confirmation of the fact of presence magnetic field on surface of loser; the confirmation of synchronism of axial rotation loser's with orbital period; the detection of decreasing of magnetic field intensity in internal layers of loser's atmosphere and the elucidation of influence of magnetic field on the formation near the loser's surface her magnitosphere; the revelation of magnetic field at the gainer, that susposses the existence of magnetic interaction between components of β Lyrae system.

Further, we reaveled new factors which affect the profiles and dynamics of aforenamed lines. In particular, of Doppler shifts of center of their emissijon correlate with loser's effective magnetic field variations (Skulskyj & Malkov 1992; Skulskyj 1993b). The variability of equivalent widths of Si II emissions with phase as well as those of the loser's absorptions lines reflects the structure of loser's magnetic field (Skulskyj 1993bc) (the changes of absolute flux in $H\alpha$ emission also are synchronous with the loser's effective magnetic field variations (Burnashev V.I. & Skulskyj M.Yu. 1991). Therefore, the magnetic field on loser's surface markendly effects on the process of matter in β Lyrae system, forming the magnetosphere around of the loser. We revealed that a zone near the loser's magnetic pole which is semiturned to massive gainer is especially important (Skulskyj & Malkov 1992; Skulskyj 1993b). Following along the power lines in outer parts of loser's magnitosphere the gas hits into gravitational zone of the gainer and creates a radial system of streams enveloping gainer. This stream system forms also around the gainer a disc-shaped structure (i.e. satellite-disc). We revealed a shift of local eclipse of the aforenamed zone loser's magnetic field (i.e. the region of the major emission formation) by the satelite-disc surrounding gainer from phase 0.97P in 1991 to the phase 0.93P in 1992 (Skulskyj 1992, 1993c): we derived the valuable conclusion that major axis of this disc is turning and precessing.

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A SEARCH FOR POSSIBLE UNRESOLVED COMPONENTS IN EIGHTEEN ECLIPSING BINARIES

T. Borkovits[1], T. Hegedus[2]

[1] Department of Astronomy, Eotvos Lorand University, Ludovika ter 2, H-1083, Budapest, Hungary

[2] Baja Observatory, Szegedi ut, PF.766., H-6500, Baja, Hungary

ABSTRACT. A total of 8507 minima times (6890 visual and 1617 photographic or photoelectric ones) of 18 eclipsing binary stars have been separated and collected from the remarkable collection of late Dieter Lichtenknecker and from the recent literature. Using the Kopal method for the analysis of the obtained (O–C) diagrams of these systems (belonging to different types of eclipsing variables) one can classify them into three categories:

1. "good cases": systems with light–time effect resulting third component with reasonable orbital and astrophysical parameters. They are AB And, TV Cas, XX Cep, AK Her.

2. "probable cases": good candidates of multiplicity but the observational data available up to now are insufficient for obtaining satisfactory description. Light–time analysis of these systems has resulted not so good solutions like for the previous group, but they can be held as noticeable targets for the future studies. These systems are U CrB, W Del, U Peg, AT Peg, ST Per.

3. "problematical cases": These systems either do not have enough data for making unambiguous identification of the sinusoidal (O–C) (due to light–time effect) and thus, we could not find a corresponding good third–body orbit, or the mathematical analysis led to results which are inconsistent with other observational or astrophysical facts. They are RT And, XZ And, OO Aql, Y Cam, RS CVn, TW Cas, CQ Cep, MR Cyg, SW Lac.

Key words: Stars: Binaries: eclipsing – period changes – light–time effect

AY LYRAE SUPERHUMPS PHOTOMETRY

V. P. Smykov
Astrophysical Observatory, Moldova State University
str. Mateevich 60, 277014, Kishinev, Moldova

ABSTRACT. During the superoutburst the superhumps with an amplitude of 0.2 mag in BV were observed. The superhumps period changed from 90 min at the maximum of the outbursts (12.8 V) up to 108 min at V = 13.2. These values are less than that obtained by previous authors.

Key words: Stars: Dwarf Novae, Binaries

Dwarf nova AY Lyr belongs to SU Uma subtype with a 24 days average cycle between the outbursts. The superoutbursts, in average, appear within 200 days.

Patterson (1979) and Szymanski and Udalski (1987) obtained precise photoelectric observations and found superhumps with a period of 108.8 and 109.4 minutes, respectively..

We have got new photoelectric BV observations during three outbursts. One of these outbursts was a superoutburst and lasted nealy 20 days. There have been obtained 105 observations in each filter.

Light at maximum of normal outbursts reached 13.4 V, at maximum of superoutbursts 12.8 V. (B-V) = 0.1 mag at maximum of the outburst.

During the superoutburst the superhumps with an amplitude of 0.2 mag in two filters were observed. The superhumps period changed from 90 min at the maximum of the outbursts (12.8 V) up to 108 min at V = 13.2. It is considerably less than it was obtained by the above mentioned authors. Unfortunately, they didn't show the phase of the outburst. If their observations of AY Lyr were taking place during the slump of the outburst, then the superhumps period should be considered 90 min exactly. Otherwise it changes from outburst to outburst.

Out of all systems of this type, which are included in the "Atlas of cataclysmic variables" by Khruzina and Shugarov (1991), the superhump period of AY Lyr is smaller than the orbital one (by nearly 20%). In such a way AY Lyr is either a unique system of the given type, or it's orbital period is not correctly determined.

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OUTBURST ACTIVITY OF THE DWARF NOVA AB DRACONIS

V. P. Smykov, L. I. Shakun
Astrophysical Observatory, Moldova State University
str. Mateevich 60, 277014, Kishinev, Moldova

ABSTRACT. Two different stages of the outburst activity were found cyclically replacing each other every 6 yr. Mean outburst cycle is 13.1327^d (1943-1991). Photometric period is $P = 0.1529581^d$. Amplitude increases with decreasing brightness.

Key words: Stars: Dwarf Novae

AB Dra was discovered by Morgenroth (1934). In GCVS it was classified as a Z Cam-subtype Dwarf nova with an outburst amplitude $\Delta V = 4.3^m$ and mean cycle $P_0 = 13.4^d$. Normal outbursts of a 3.1^d width and 8.6^d wide are observed. On the base of spectral observations, Thorstensen & Freed (1985) showed the importance of orbital period 0.15198 days. However, the data of Voloshina & Shugarov (1989) period correspond to a photometric period 0.151662^d.

We have obtained new 40 photographic B observations in 1986 and 284 photoelectric BV observations in 1991. Totally 13 outbursts were detected. The amplitude of the orbital changes at the outburst maximum is smallest and is equal to 0.05^m. With falling brightness down to $13.5 - 14.0^m$ the amplitude increases to 0.3^m.

The obtained observations do not agree with a period 0.151662^d. For more precise determination we have used the longest rows of our observations and that of Voloshina & Shugarov (1989). The period search was done separately both for the maximum of the outburst and for the slump of the brightness in connection with a rather different amplitude. Besides that the observations in each group were shifted to one mean brightness. As a result we had found a period which satisfies all the observations. The light elements are the following:

$$\text{Max HJD} = \underset{\pm 4}{2445938.7427} + \underset{\pm 3}{0.1529531} \cdot E_0$$

The shape of the light curve is non-sinusoidal. It has a narrower maximum and a wide minimum. In such a way the photometrical period AB Dra differs from the spectral as it is.

The determined parameters of average outburst: brightness $m_B = 12.8^m$ at maximum, $m_B = 14.9^m$ at minimum with a full amplitude $\Delta B = 2.1^m$. The width of the outburst at a level $m_B = 13.5^m$ is $W = 2^d$, the duration of the outburst about 6 days.

The received 13 moments of the outbursts AB Dra were completed by all available literature data. And as a result, 195 moments were drawn up. The intervals of time between two consecutive outbursts change from 7^d to 20^d with an average cycle of 13.1327^d. Dependence $(O - C)$ on JD shows that AB Dra has two alternating periods of outburst recurrence – 12.487^d and 13.893^d, replacing each other with a cycle of $\Pi = 2200^d$. It is possible to say that there exist two states: "active", when the outbursts occur more frequently, and "non-active", when the outbursts rarely occur. Similar result was found out earlier for some other dwarf novae (Shakun 1987, 1988ab).

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MOMENTS OF EXTREMA OF THE CATACLYSMIC VARIABLE TT ARI

I.V. Spychka, V.S. Kaserkevich
Astronomical Observatory, Lviv State University,
Lomonosova 8, Lviv 290005 Ukraine

ABSTRACT. 44 moments of extrema of TT Ari in B and V are listed. The phases show very large scatter due to physical variability of the system.

Key words: Stars: Cataclysmic: TT Ari

The star was observed at the 50–cm telescope of the Lviv University Observatory in the instrumental BV systems. The star "c" (Götz 1985) was used for comparison. The data were smoothed by the method of "running parabolae" (Andronov 1990) with a value $\Delta t = 0.05^d$ adopted for recent international campaign (Tremko et al. 1994). The extrema are listed in Table 1. They may be used with other data to study period variations. The phases $E + \varphi = (t - T_0)/P$ are computed according to the ephemeris by Rößiger (1988): Max HJD=2437646.672+0.13277082$\cdot E$. One may note apparent shifts between the corresponding extrema in B and V up to $0.1P$. This may be caused by "20–min" physical variability of the system which deforms light cures obtained not simultaneously in both bands. Previous results of our observations were published by Wenzel et al. (1986) and Tremko et al. (1990). Detailed analysis will be presented elsewhere.

Table 1. Characteristics of the extrema

t-2440000	$E+\varphi$	Δm	Rem
8178.550	79323.740±.013	−0.46±.05	Max V
8178.538	79323.651 .031	−1.06 .02	Max B
8183.403	79360.295 .066	−0.27 .02	min V
8183.463	79360.745 .056	−0.32 .02	Max V
8183.533	79361.274 .163	−0.22 .03	min V
8183.391	79360.203 .030	−0.97 .02	min B
8183.472	79360.814 .072	−1.02 .03	Max B
8183.537	79361.298 .078	−0.83 .03	min B
8187.415	79390.506 .165	−0.33 .04	Max V
8187.431	79390.632 .034	−0.99 .02	Max B
8188.425	79398.117 .067	−0.25 .02	Max V
8188.462	79398.398 .042	−0.18 .03	min V
8188.550	79399.061 .064	−0.30 .03	Max V
8188.422	79398.096 .033	−0.95 .02	Max B
8188.463	79398.400 .032	−0.85 .02	min B
8188.500	79398.680 .027	−1.00 .03	Max B
8502.600	81764.414 .011	−1.01 .03	min B
8503.612	81772.035 .050	−0.38 .03	Max V
8503.649	81772.311 .022	−0.32 .02	min V
8503.603	81771.966 .041	−1.05 .03	Max B
8503.644	81772.272 .007	−0.96 .02	min B
8512.577	81839.557 .087	−0.30 .02	Max V
8512.648	81840.094 .063	−0.25 .03	min V
8512.613	81839.825 .023	−0.92 .03	min B
8512.684	81840.362 .067	−0.98 .02	Max B
8535.526	82012.403 .048	−1.01 .02	Max B
8890.425	84685.425 .040	−0.30 .03	min V
8890.464	84685.717 .118	−0.40 .05	Max V
8890.513	84686.083 .348	−0.33 .03	Max V
8890.461	84685.696 .070	−0.95 .03	min B
8890.513	84686.084 .021	−1.04 .03	Max B
8891.440	84693.066 .047	−0.35 .02	Max V
8891.483	84693.392 .027	−0.29 .02	min V
8891.413	84692.863 .049	−1.05 .03	Max B
8891.481	84693.375 .073	−1.01 .03	min B
8891.518	84693.655 .085	−1.05 .03	Max B
8893.409	84707.897 .065	−0.22 .04	min V
8893.400	84707.828 .093	−0.84 .06	min B
8915.447	84873.886 .067	−0.37 .03	Max V
8915.495	84874.248 .061	−0.27 .03	min V
8915.552	84874.670 .063	−0.41 .02	Max V
8915.432	84873.769 .076	−1.09 .03	min B
8915.443	84873.850 .069	−1.09 .04	Max B
8915.493	84874.231 .130	−0.97 .04	min B

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STATISTICAL RESTORATION OF SECONDARY MINIMA DEPTHS FOR ECLIPSING VARIABLE STARS AND SPECIFICATION OF THEIR EVOLUTIONARY TYPES

E. M. Svirskaya
Chelyabinsk University, Physics Department.
Russia, 454136, Chelyabinsk-136, ul.Br.Kashirinikh, 129
E-mail: nig@cgu.chel.su

ABSTRACT. 30 unknown magnitudes of secondary minima depths for eclipsing variable stars are restored by ZET – method. Evolutionary types of some eclipsing variable stars are specified on the basis of obtained data.

Key words: Stars: Binaries: Eclipsing; secondary minima depths

In this paper secondary minima depths A(2) of eclipsing variable stars are computed by statistical method, namely, ZET algorithm (Zagoruiko et al. 1985). The statistical approach is necessary for stars with uncertain orbital elements.

ZET algorithm is intended to predict uncertain elements in empirical tables "object–property" and to verify the table or part of it. In tables "object–property" with dimension $M \cdot N$, the lines (objects) have numbers $i = 1...M$ and columns (properties) – $j = 1...N$.

Uncertain element a(i,j) in ZET algorithm is predicted on the basis of local linearity principle, i.e. under assuming the linear dependence between lines and/or columns, most similar with line i and/or column j.

7 characteristics of stars from Svechnikov & Kuznetsova (1990), most informative for predicting secondary minima depths, were used to restore 30 uncertain magnitudes A_2 for DM–type eclipsing variable stars: the mass ratio of main and secondary components M_1/M_2, the luminosity of more massive component L_1 (in units of $L_1 + L_2 = 1$), the ratio of surface brightnesses of more massive and less massive components J_1/J_2, the value of orbital inclination i, the absolute bolometric magnitude M_{2b}, the main component radius r_1 (in units of orbital major semi–axis) and the spectral class of the more massive component Sp_1).

The table with 8 parameters such as A_1/A_2, M_1/M_2, L_1, J_1/J_2, i, M_{2b}, r_1, Sp_1, for 392 DM-type stars were compiled (A_1– main minima depths). All certain elements of first column were verified . The average error of verification was 3.87%. This result shows application expediency of ZET method for restoration of uncertain secondary minima depths on the basis of this table.

Actually, approximately 2/3 magnitudes A_2 were restored with the error about 5%, 1/3 magnitudes – with the error about 10%, and prediction error only of two magnitudes A_2 was greater than 10%, but less then 20%. It turned out that calculated by ZET method magnitudes A_2 for 27 eclipsing variable stars in fact correspond to secondary minima depths of DM-type stars according to classification of Svechnikov et al. (1980). However, the calculated magnitudes A_2 for stars: GU Car, V566 Sco and V585 Sco exceed unity, although magnitudes A_1 are much less than unity according to GCVS (Kholopov 1985-1987). Such differences between depths of main and secondary minima in accordance with classification of Svechnikov et al. (1980) are more characteristic for SD-systems. Therefore these stars, probably, are not DM–type stars, but belong to SD–systems.

The obtained results allow us to conclude that effective prediction of secondary minima depths for eclipsing variable stars by ZET method and specification of their evolutionary types on this basis are possible.

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POLARIZATION ECLIPSE MODEL OF THE WOLF–RAYET BINARY V444 CYGNI WITH CONSTRAINS ON THE STELLAR RADII AND AN ESTIMATE OF THE WOLF–RAYET MASS–LOSS RATE

N. St–Louis[1], A. F. J. Moffat[1], L. Lapointe[1], Yu. S. Efimov[2], N. M. Shakhovskoy[2], G. K. Fox[3], V. Piirola[4]

[1] Departement de Physique, Universite de Montreal, C.P. 6128, Succ.A Montreal (Qc), H3C 3J7, Canada, and Observatoire du Mont Megantic

[2] Crimean Astrophysical Observatory, P/O Nauchny, 334413, Crimea, Ukraine

[3] Department of Physics and Astronomy, University of Glasgow Glasgow G12 8QQ, Scotland, UK

[4] Observatory and Astrophysics Laboratory, University of Helsinki Tahtitornmaki, SF–00130 Helsinki 13, Finland

ABSTRACT. We present an improved analytical model as well as a new set of multiwavelength observation of the polarization eclipse of the Wolf–Rayet binary V444 Cygni (WN5+O6). Comparing the model with the observations yields an estimate of the O and Wolf–Rayet star radii as well as of the Wolf–Rayet mass–loss rate. For the O star we find R = 8.5 $R_\odot$ and for the Wolf-Rayet star R<4 $R_\odot$. This values are in agreement with those derived by Cherepashchuk et al. from the detailed analysis of multiwavelength light curves.

For the Wolf-Rayet mass-loss rate we obtain $\dot{M} = 7.5{\cdot}10^{-6} M_\odot/\mathrm{yr}$, which is compatible with the dynamical values obtained from the rate of orbital period increase and with the value of dM/dt determined from the orbital double-wave modulation in polarization, but is at least 3 times smaller than the values derived from free–free radio fluxes and modeling of infrared spectral lines. However, no allowance has been made in calculating the mass-loss rates for inhomogeneitics, for which evidence is increasing in hot star winds. If the wind of the WR star V444 Cygni is found to be clumpy, the radio/IR mass-loss rates are likely to be overestimated because of their dependency on the square of density. In such case, these values would probably have to be significantly decreased, bringing them closer to the polarization estimates, for which clumpy winds are irrelevant, providing the electron scattering remains optically thin.

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Key words: Stars: Wolf–Rayet, V 444 Cygni

"20–MIN" OSCILLATIONS OF THE CATACLYSMIC VARIABLE TT ARI

J. Tremko[1], I. L. Andronov[2], L. L. Chinarova[2], M. I. Kumsiashvili[3],
R. Luthardt[4], G. Pajdosz[5], L. Patkós[6] S.Rößiger[4], S. Zola[5,7]
[1] Astronomical Institut of the Slovak Academy of Sciences,
059–60 Tatranska Lomnica, Slovakia
[2] Department of Astronomy, Odessa State University,
T.G.Shevchenko Park, 270014 Odessa, Ukraine
[3] Mount Kanobili Astrophysical Observatory
Georgian Academy of Sciences, 383762 Abastumani, Georgia
[4] Sonneberg Observatory, PSF 55–27/28, O–6400 Sonneberg, Germany
[5] Astronomical Observatory, Pedagogical University
ul.Podchorążych 2, 30–084 Kraków, Poland
[6] Konkoly Observatory, P.O.Box 67, H–1525 Budapest, Hungary
[7] Astronomical Observatory, Jagiellonian University
ul.Orla 171, 30–244 Kraków, Poland

ABSTRACT. Results based on 16 nights in B, 3 in UBV and 1 in UBVRI are presented. Periodograms for detrended nightly runs showed significant peaks at different frequences from 28 to 103 c/d. Most prominent of them correspond to the best fit periods 23.7, 15.2, 27.5 and 51.6 min. Characteristics of the peaks are listed in tables. It seems that in TT Ari we observe contributions of several mechanisms of instability with similar time scales rather than a single QPO with secular decrease of the cycle.

Key words: Stars: Cataclysmic Variables; QPOs; TT Ari.

TT Ari shows a wide variety of time scales characterizing its variability at 8 seconds (Kozhevnikov 1985), ≈ 20 min, 3 hours (Smak and Stępień 1969), ≈ 5 hours (Wenzel et al. 1986, Tremko et al. 1992), 3.76^d (Semeniuk et al. 1976), few years (Hudec 1984). Some international campaigns were organized (cf. Wenzel et al. 1986, Tremko et al. 1993, 1995). Here we present some results based on the observations obtained in 1988.

The presence of "Quasi–periodic fluctuations with a cycle length of 14–20 min and an amplitude up to 0.2^m in B" was detected by Smak and Stępień (1969). Williams (1966) argued for three (!) predominant periodicities with $P = 13.9$, $P = 17.6$ and $P = 42.2$ minutes with equal amplitudes of 0.028^m of the first two waves and 0.016^m of the third wave. Semeniuk et al. (1987) reported on a trend in this "period" the value of which had decreased from 27 minutes in 1961 to 17 minutes in 1985. Even at low state ($V = 16.5^m$), when accretion is ceased, the variations are present with separation between the prominent maxima from 4 to 30 minutes (Shafter et al. 1985). Udalski (1988) obtained values from 18 to 22 minutes on different nights during the observational season 1987/88. The oscillation most stable in phase for 4 runs obtained by Andronov et al. (1992) corresponds to 60.7±0.6 c/d (23.7 min). This differs from the value 15.3 min obtained by Hollander and van Paradijs (1992) from observations taken three months earlier.

The designation of the observational runs are the following. First two letters correspond to the observatory (AB – Abastumani, KR - Kraków, PI – Piszkesteto, SB – Sonneberg, SP – Skalnate Pleso). Three digits correspond to (HJD–2447000). After that a letter indicating the filter may be present. If not, than the default instrumental system is B. Detailed description of the instruments and discussion on other time scales is presented by Tremko et al. (1995). Tables of observations for the runs MO 335 (obtained by D.E.Kolosov from Moscow) and OD 448 (obtained by A.I.Movchan and A.N.Rudenko from Odessa) were published by Andronov et al. (1992) and used for the present analysis.

To remove a "3–hour" trend we have used the method of "running parabolae" (Andronov 1990) with a filter half–width $\Delta t = 0.05^d$. After that the residuals $O - C$ were analyzed by using a one–harmonic fit with unknown zero level (the program FOUR–1 by Andronov (1994)). All periodograms were computed for the same frequency range from 0.5 to 200 cycles/day. As a characteristic of the separation between the "independent frequencies" we have chosen $\Delta f = (n-1)/(n(t_n-t_1))$, where n is the number of observations and t_k, $k = 1...n$ are the moments of observations in a run (Andronov 1994). The value of Δf for the mean weighted periodogram was determined as a weighted mean from Δf obtained for the individual runs.

Periodograms obtained in different colors during one night show nearly similar behaviour both for UBV observations obtained in Abastumani and for UBVRI (Piszkesteto). However, the relative heights of the peaks at fixed frequencies are wavelength–dependent. Thus the most prominent peak may occur at different frequencies. Highest peaks for these runs are listed in Table 1. Sometimes a second peak is listed corresponding to the frequency seen at other wavelengths. One may note an apparent frequency trend observed during three subsequent nights in Abastumani.

The designations in Tables 1–3 are: $n-$ the number of observations, σ_O- the r.m.s. deviation from the mean, f is the best fit frequency measured in cycles/day, $S(f) = \sigma_C^2/\sigma_O^2 = 1-\sigma_{O-C}^2/\sigma_O^2$ and $Lp = -\lg Pr$, where Pr is the "false alarm probability", i.e. the probability that the peak of the height equal or more than the observed one may appear for the "white noise" signal. The best fit semi–amplitude r may be estimated as $r = \sigma_O\sqrt{2\,S(f)}$.

Table 1. Characteristics of highest peaks at a periodogram for multicolor observations

run	σ_{O-C}	f	$S(f)$	L_p
AB 421 $\Delta f = 13.6$ c/d, n=60				
U	0.047	76.7± 2.2	0.29	3.0
B	0.035	74.5± 3.3	0.26	2.4
V	0.039	73.8± 2.2	0.33	3.7
V	0.039	111.7± 1.4	0.25	2.3
AB 422 $\Delta f = 13.9$ c/d, n=58				
U	0.053	100.6± 1.9	0.24	2.0
B	0.040	87.3± 1.6	0.32	3.3
V	0.037	100.6± 2.0	0.31	3.3
AB 423 $\Delta f = 11.9$ c/d				
U	0.053	186.6± 1.9	0.22	2.5
U	0.053	110.1± 2.0	0.19	1.9
B	0.038	109.0± 1.7	0.21	2.3
V	0.036	111.4± 1.6	0.26	3.3
PI 454, $\Delta f = 5.7$ c/d, n=83				
U	0.049	91.2± 0.6	0.20	2.2
B	0.041	133.1± 0.7	0.16	1.4
V	0.039	40.0± 0.9	0.17	1.5
R	0.041	39.7± 0.8	0.19	2.1
I	0.038	73.4± 0.9	0.19	1.9

This confirms good correlation between variations in different spectral bands, which differ in amplitudes but not in phases. Some differences in the periodograms may be attributed to uncorrelated variations.

Tremko et al. (1995) proposed a method to determine the effective colours of variations which have the same shape (generally not sinusoidal) but wavelength–dependent amplitudes by using the autocovariation matrix (AKM) of the brightness variations in different colours. The colours of "20–min" observations are more blue, than of the "3–hour wave" which is more blue than the mean emission. E.g. the values U–B= -1.04^m, -1.24^m, -1.35^m and B–V=0.19^m, 0.05^m, 0.12^m for "mean brightness", "fast" and "slow" variations, respectively.

For the sinusoidal fits the effective colours may in principal be determined from the amplitude ratios and show results similar to that obtained from the autocovariation analysis. E.g. for the run AB 423 Δ(U–B) $= -2.5\lg(r_U/r_B) = -0.24^m \pm 0.33$ (in respect to the mean color). The value is close to that

(-0.31^m) obtained from the ACM analysis, but the error estimate is very large because the relative accuracy of the amplitude of the aperiodic signal is $\approx 25\%$. Corresponding error estimates obtained by using the ACM method are by $4-6$ times smaller and the may be recommended for determination of the colours.

A variety of periodogram shapes is observed for "long" one–color runs. No peak appears during all the runs, despite some of them occur many times. Characteristics of four highest peaks corresponding to all runs are listed in Table 2. They do not show presence of one coherent period, but may be useful for future comparison with other data. One may note a significant difference of the periodograms obtained during a same night (runs SB 415 and SP 415; PI 454 and SP 454) but in not equal time intervals. Even the periodograms for the overlapping time intervals from different observatories show different shapes of $S(f)$, because the segments cover different branches of the light curve. This shows remarkable variability of the cycle length at a very short (hour) time scale. One may note the extremely low probabilities of the random appearance of such high peaks. Apparently very low "false alarm probability" computed as described by Andronov (1994) does not argue for *coherent* oscillations. It only indicates that the signal is not "white noise". Not all of them are independent, but the aliases often correspond to the peaks of the height compared with that of the "true" peak.

Most prominent peaks at the weighted mean periodogram are listed in Table 3. The highest peak at $P = 23.7$ min does not obey the "Period–Time" relationship by Semeniuk et al. (1987). However, the second peak at 15.2 min does obey and coincides with the value 15.3 min obtained by Hollander and van Paradijs (1992). They discussed some models of such a decrease and argued that the "period" may be a beat one between the Kepler frequency at a magnetospheric radius and a rotational frequency of the white dwarf.

The model of Hollander and van Paradijs (1992) may explain drastic changes in the "period" without significant variations of the mean luminosity. However, it seems that TT Ari shows contributions of several instability mechanisms with similar time scales rather than a single QPO.

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Table 2. Characteristics of four highest peaks at periodograms for "long" runs

run	n	σ_{O-C}	f_1	$S(f)$	L_p	f_2	$S(f)$	L_p
SB 412	293	0.039	58.3± 0.4	0.22	13.8	68.3± 0.6	0.12	6.4
SB 413	401	0.042	32.1± 0.6	0.05	2.4	39.2± 0.5	0.05	2.9
SB 414	290	0.050	76.5± 0.9	0.12	6.7	85.3± 0.9	0.09	4.3
SB 415	370	0.037	94.8± 0.5	0.12	8.8	103.3± 0.4	0.14	10.1
SP 415	578	0.036	47.0± 0.2	0.14	16.5	62.9± 0.2	0.15	19.1
MO 435	868	0.044	29.9± 0.4	0.10	18.8	59.9± 0.3	0.13	23.7
KR 437	501	0.048	23.7± 0.6	0.07	6.8	43.9± 0.6	0.06	5.3
KR 438	562	0.045	27.9± 0.4	0.18	22.2	55.2± 0.5	0.09	10.0
SP 444	592	0.039	51.6± 0.3	0.09	10.0	61.2± 0.3	0.14	18.1
OD 448	855	0.054	44.0± 0.4	0.07	11.2	60.0± 0.2	0.14	26.3
SP 450	745	0.040	56.9± 0.2	0.08	11.3	77.9± 0.2	0.11	17.3
SP 452	468	0.041	52.9± 0.3	0.22	23.8	81.9± 0.3	0.11	10.6
SP 454	640	0.043	27.4± 0.4	0.09	11.2	44.1± 0.3	0.14	18.4
KR 456	709	0.039	26.7± 0.5	0.07	8.7	59.4± 0.4	0.07	9.7
KR 471	357	0.043	59.2± 0.6	0.13	9.5	73.3± 0.7	0.16	11.9
KR 477	715	0.044	25.4± 0.4	0.09	12.7	34.0± 0.6	0.05	5.5

Table 2 (continued)

run	Δf	f_3	$S(f)$	L_p	f_4	$S(f)$	L_p
SB 412	6.3	92.9± 0.4	0.27	17.8	112.7± 0.5	0.13	7.2
SB 413	5.7	58.7± 0.6	0.08	5.5	91.9± 0.5	0.13	10.9
SB 414	8.1	98.6± 0.9	0.10	5.3	130.5± 0.9	0.06	2.6
SB 415	5.3	109.6± 0.5	0.09	5.8	132.9± 0.6	0.06	3.3
SP 415	4.3	90.9± 0.3	0.09	10.3	104.5± 0.2	0.10	11.6
MO 435	7.3	94.8± 0.3	0.14	27.8	112.4± 0.3	0.14	26.7
KR 437	7.2	53.9± 0.3	0.26	30.6	73.5± 0.5	0.10	10.3
KR 438	6.1	78.6± 0.4	0.16	18.8	108.4± 0.5	0.07	6.9
SP 444	4.0	92.1± 0.4	0.10	11.4	141.3± 0.2	0.09	10.1
OD 448	4.2	86.6± 0.2	0.08	14.3	95.9± 0.3	0.06	10.3
SP 450	3.6	108.5± 0.2	0.10	14.9	113.7± 0.2	0.08	12.1
SP 452	5.6	102.4± 0.4	0.09	8.4	134.4± 0.5	0.10	8.6
SP 454	4.3	61.4± 0.2	0.15	20.6	67.3± 0.2	0.10	12.1
KR 456	5.7	83.7± 0.3	0.09	13.5	103.7± 0.4	0.06	8.4
KR 471	9.7	100.2± 0.7	0.12	8.5	114.6± 0.8	0.10	7.0
KR 477	5.4	62.6± 0.5	0.06	7.1	141.1± 0.5	0.07	9.9

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Table 3. Characteristics of peaks of a mean periodogram with a "false alarm" probability less than 10^{-50}.

f, c/d	P,min	$S(f)$	L_p	r
27.9± 0.2	51.6	0.0497	57.3	0.014
52.4± 0.2	27.5	0.0515	60.9	0.014
60.9± 0.1	23.7	0.0784	116.2	0.017
71.7± 0.2	20.1	0.0463	50.4	0.013
91.4± 0.3	15.7	0.0493	56.5	0.014
94.5± 0.2	15.2	0.0536	65.2	0.014
113.4± 0.2	12.7	0.0482	54.2	0.013

EXCITATION CONDITIONS OF IRON FLUORESCENT LINES IN SOLAR FLARES

U. Sh. Bayazitov
Theoretical Physics Department, Bashkirian Pedagogic Institute,
Okt. Revolutsii Str, 3-A, Ufa 450000 Bashkortostan, Russia
Tel: (3472) 223528

ABSTRACT. The conditions of the excitation of the fluorescent lines Fe I 4063, 4123 Å in the solar flares are discussed based on the previous work (Bayazitov U.Sh., Sakhibullin N.A., *Pisma Astron. Zh.*, 1991, **17**, 337). These conditions are not challenging the theoretical picture and the observational data for these objects.

Key words: Stars: spectra; Sun : flares

Fluorescent iron lines Fe I (43) 4063, 4132 Å are rare phenomena because they first of all have been discovered in extremely young T Tauri stars (Joy, *Ap.J.*, 1945, **110**, 424) and further in solar flares (Cowley & Marlborough, *Ap.J*, 1969, **152**, 803). The explanation of this anomaly strengthening has been given by Herbig (*P.A.S.P.*, 1945, **57**, 156) – fluorescent iron lines Fe I 4063, 4132 Å caused by coincidence of the Fe I(43) 3969 Å line and H + H Ca II blend.

This problem for the solar flares has been investigated in a number of our works (Bayazitov & Sakhibullin, 1991, *Pisma Astron. Zhurn.*, **17**, 377 and references in this paper). Our results have been obtained by the detailed simulations of H +H Ca II radiation field in our Non–LTE calculations. The method has been described in our work (1990, *Pisma Astron. Zhurn.*, **16**, 560). We have used the semiempirical hydrostatic chromosphere models of solar flares (Machado & Linsky, 1975, *Solar Phys.*, **42**, 803). By means of the numerical experiments with various line broadening parameters it is shown that the main reason for the *in* lines fluorescence is the velocity gradient in the flare atmosphere. It was concluded, that this fluorescence is connected with H line because this line is more broader that H Ca II line in the solar flares. These circumstances determine the dynamic picture in these objects – the gas flowing down toward to photosphere by negative velocity gradient.

How this dynamics agrees with observational data?

It is well known that the spectral line profiles are asymmetrical in the many solar flares (Svestka: 1976, *Solar flares*). Ishimoto and Kurocawa (1984, *Solar Phys.*, **93**, 105) observed the line center shifts and the asymmetry in the Hp red part of profile in the flares near the Solar disc center. Authors have interpreted this phenomenon as the downflowing which has velocities in range of 40 – 100 km/s. Canfield et al. (1990, *Ap.J.*, **348**, 333) also observed red shifted H flare lines with the velocities approximately equal to 40 km/s.

All these observational data are agree with our numerical modeling results. We also add to this new fact – the downflowing of solar flares gas has the braking and this fact may be explained by the gas friction of dense lower chromosphere and photosphere layers. The estimates of this braking were published in our work (1990, *Pisma Astron. Zhurn.*, **16**, 560).

The conclusions are the following. The presence of the fluorescent lines Fe I 4063, 4132 Å proofs the presence of downflowing gas in solar flares. This stream has negative velocity gradient. Therefore the hydrostatic atmosphere models of the solar flares seems to be inadequate to the real conditions.

SIMPLE EXPRESSION FOR THE LINEAR STARK BROADENING CONSTANT OF HYDROGEN LINES

U. Sh. Bayazitov
Theoretical Physics Department, Bashkirian Pedagogic Institute,
Okt. revolutsii Str, 3-A, Ufa, 450000, Bashkortostan, Russia.
Tel:(3472) 223528.

ABSTRACT. A simple analytic expression is presented allowing to take into account the Stark broadening constant of hydrogen lines.

Key words: Line profiles, Stark broadening

The main line broadening factor of hydrogen lines in stellar photospheres is the Stark broadening. But in stellar chromospheres the sufficient micro– and macro turbulent velocities are presented. Therefore if we use chromosphere models for the hydrogen line profile calculations the Doppler broadening to be under consideration. The simultaneous treating of Stark and Doppler broadening is the serious computation problem. In this paper the simple expression for the linear Stark broadening constant of hydrogen lines is presented. With the aid of our above mentioned expression the simultaneous consideration of Stark and Doppler line profile broadening becomes a very easy process.

In the classical Weisskopf theory all pressure dumping parameters γ_n are expressed by common formulae:

$$\gamma_n = 2\pi\rho_0^2 N v \quad (1)$$

(Mihalas 1978). The linear Stark parameter γ_2 from these theory is equal:

$$\gamma_2 = 2\pi\left(\frac{C_2}{v}\pi\right)^2 N v \quad (2)$$

(Mihalas 1978). Let's try to estimate the mean value of relationship constant $\bar{C}_2$ for all Stark components:

$$\bar{C}_2 = \frac{3h\bar{n_k}}{4\pi m} = 1.738\bar{n_k}, \quad (3)$$

where $\bar{n_k} = n(n-1)/2$ if $n >> 1$.

So, from Eq.(1) and Eq.(2) we have:

$$\gamma_2 = \frac{2\pi^3}{4}(1.738^2 \cdot n^2(n-1)^2)N/v \quad (4)$$

Taking in the consideration the linear Stark effect depending on N_e and N_p we then may rewrite our Eq. (4) in the following manner:

$$\gamma_2 = 4.683 \cdot 10^1(n^2(n-1)^2)\times \times (N_e/v_e + N_p/v_p) \quad (5)$$

where

$$v_e = \left[\frac{8kT}{\pi}\left(\frac{1}{m_H}+\frac{1}{m_e}\right)\right]^{1/2} \approx \left[\frac{8kT}{\pi m_e}\right]^{1/2} = 6.212 \cdot 10^5\sqrt{T} \quad (6)$$

and

$$v_p = \left[\frac{16kT}{\pi}\left(\frac{1}{m_H}\right)\right]^{1/2} = 2.050 \cdot 10^4\sqrt{T} \quad (7)$$

In the conclusion we can write down the simple expression for the linear Stark parameter:

$$\gamma_2 = 46.83(n^2(n-1)^2)\times \times (N_e 1 6.212 \cdot 10^5 + N_p 1 2.050 \cdot 10^4)/\sqrt{T} \quad (8)$$

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ON THE SPECTROPHOTOMETRIC STAR CATALOGUE

A. V. Dragunova, V. F. Karamysh, N. S. Komarov
Astronomical Observatory, Odessa State University,
T.G.Shevchenko Park, Odessa 270014 Ukraine
E-mail: root@astro.odessa.ua

ABSTRACT. The data on energy distributions in spectra of 555 stars are reduced to one system and averaged. The results of stellar spectrophotometry are used which have been obtained at astronomical institutions in Moscow (Sternberg Astronomical Institute), S.–Petersburg (Main AO RAS), Alma – Ata (Astrophysical Institute), Crimea (Simpheropol State University, CrAO), Odessa (OAO) during 25 recent years. For only 180 stars the scatter of individual data (of catalogues) does not exceed 10% in all the considered wavelength range (320–1080 nm) for B – M spectral types.

Key words: Stars: fundamental parameters, energy distribution; Catalogs

For three recent decades the electrospectrophotometry has advanced in many astronomical organizations at the territory of the former USSR. Energy distributions – E(λ) – are obtained in spectra of several hundreds of bright stars. It should be noted that due to the influence of demands of purely applied character the technique of obtaining E(λ) data was unified. Similar optical – mechanical systems were used as well as analogous procedures of observations of stellar spectra and subsequent calculations. With electronic engineering development, often parallel to it, only register electronic devices were modified as well as storage units and processors of observational information. Errors of results obtained also proved to be the same, as a rule, of the order of 2–3% (to 5%) in the most powerful energy range of a spectrum and 5–10% at the edges of the observed spectral bands including the ultraviolet range.

However, the comparison of spectrophotometry results obtained by different authors has shown the large discrepancies – up to several dozens (!) of percents sometimes.

Here an attempt is made to obtain the mean energy distributions in stellar spectra without giving preference to any catalogue, and merely excluding from considerations the stars for which divergences are more than 25%. All the materials from stellar spectrophotometry (catalogues) published up to 1989 and obtained at traditional centers of such works have been taken: GAISH (Voloshina et al. 1982, 1983; Glushneva et al. 1984, 1988; Kolotilov et al. 1980; Shenavrin et al. 1989), MAO RAS (Alexeyev et al. 1978, 1984, Alexeyeva et al. 1988), AFI (Kharitonov et al. 1978, 1988, Tereshchenko et al. 1987; Glushkova et al., 1988), CrAO (Burnashov 1982), Simferopol State University (Terez 1987), Odessa AO (Komarov et al. 1983).

All the energy distributions in spectra of stellar radiation are reduced to the OAO Vega system (Komarov et al. 1978) in order to exclude any systematic discrepancies related to the use of different systems of primary standards. For visual demonstration in analyzing and averaging all the data in total, a graphic method has been used. With that, obvious erroneous data have been excluded, and namely: "springing out" dots, "tails", displacements of some parts in the wavelength or in stellar magnitudes etc. Then the averaging is made of data in all the wavelength range inherent to original catalogues from every star. So, two groups of data on mean E(λ) have been obtained: from 320nm to 900nm and from 320nm to 1080nm.

The resulting catalogue recorded on magnetic diskettes comprises 555 stars. Only 180 of these have been obtained from initial data, the scatter in which does not exceed 10%, and in 75 stars it is not more than 5%.

Average values obtained are noted to be ambiguous, i.e. not uniform, as in the averaging of different stars, a various quantity of original catalogues – from 2 to 12 – participated. And a great number of "participants" did not always contribute to the result improvement – for most G– and K–type stars, the error range still remained large, over 10%.

No systematic divergences of initial catalogues are found. Neither is detected any certain dependence of "error corridor width" proximity of results upon a spectral type of stars. It should be only noted that in all A7 – type stars considered the discrepancy between E(λ) data all over the range does not exceed 7%.

The catalogue of mean E(λ) is diskette recorded and a list of stars is enclosed, the initial data of proximity ranges being indicated from four parts of the spectrum: the "blue" (320–450nm), the "yellow" (450–550nm), the "red" (550–750nm) and near–IR (750–900nm). A part of the spectrum from 900 to 1080nm is mainly represented by one, and more rarely, by two original catalogues.

The Catalogue will be published in the next issue of the "Odessa Astronomical Publications".

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FUNDAMENTAL CHARACTERISTICS OF COOL GIANT STARS

L. V. Korotina, N. S. Komarov
Astronomical Observatory,Odessa State University,
T.G.Shevchenko Park,Odessa,270014,Ukraine
E-mail: root@astro.odessa.ua

ABSTRACT. The methods are suggested for determination of fundamental characteristics of cool giant stars from photometry in the Geneva and Gildenkern systems, using for calibration of a great number of standard stars. The catalogues of T_{eff}, lg g, [Fe/H] are obtained for 1000 stars and 600 stars in Geneva-Observatory and Gildenkern systems, respectively.

Effective temperature scales and gravity accelerations are determined. The metallicity distribution is obtained according to the spectral types. The metallicity data of stars, belonging to dynamical groups and open clusters, have not confirmed the presence of a linear "metallicity – age" relationship. A conclusion is made on the existence of two age groups among disc giants. The absolute stellar magnitudes (M_v), the bolometric stars magnitudes (M_{bol}), the luminosities (L), the radii (R), the masses ($\mathcal{M}$) for 1370 stars by using the catalogue values of the effective temperatures (T_{eff}), gravites (g), metallicities ([Fe/H]) have been determined. The relation of those values to a spectral type and metallicity have been obtained.

Key words: Stars: characteristics.

LITHIUM, BERYLLIUM, BORON AS INDICATORS OF MATTER EVOLUTION

V. G. Klochkova, V. E. Panchuk
Special Astrophysical Observatory RAS
Nizhniy Arkhyz, Stavropl'skii Kraii, 357147 Russia
E-mail: vkloch@sao.stavropol.su

ABSTRACT. A historic review of the 293 papers, contained as the results of observations and the description of the processes of production and destruction of the light elements Li, Be, B are presented.

Key words: Stars: abundances, evolution

The results of Li, Be, B observations are grouped in the next sections:

1. The main sequence stellar atmospheres.
1.1. The estimation of the average abundances and the study of the Li abundance slope at low temperatures.
1.2. The discovery and the study of the Boesgaard gap in the Li behaviour.
1.3. The relation between the Li abundance and the different age parameters: chromospheric activity, rotation velocity, metallicity, belong to young or old binary systems.
1.4. The evolutionary variation of Li abundance, determined by spectroscopy of the stars in the clusters with a different age.
1.5. The investigation of the Li isotopes ratio.
1.6. The Li, Be, B abundances in the atmospheres of chemically peculiar and metallic stars.
1.7. The Li abundance in the atmospheres of RS CVn type stars.
1.8. The Li abundance in the atmospheres of blue strugglers.
2. The atmospheres of high luminosity stars.
2.1. The normal subgiants, giants and supergiants.
2.2. The peculiar objects: stars with poor G-band, CH-stars, S, SC, CS, C and Ba-stars.
2.3. Lithium in the atmospheres of the giants, members of open clusters.
2.4. The Li abundance in the Magellanic Clouds.
3. The atmospheres of pre-main sequence stars.
4. The estimation of the interstellar Li, Be, B abundances.
5. The Li study in halo subdwarf atmospheres.
5.1. The independence of the Li abundance on metallicity for metal poor subdwarfs (Spite plateau).
5.2. The ratio of Li isotopes for halo subdwarf atmospheres.
6. The Be, B study in the halo subdwarf atmospheres.

The review of the processes of Li, Be, B origin and destruction is divided on the next sections:

7. The synthesis by galactic cosmic rays spallation reactions.
8. The synthesis by spallation reactions into the stellar atmospheres.
9. The synthesis into the envelope of stars and under explosions.
10. The synthesis under the neutronization processes.
11. The influence of diffusion processes on the observed abundances.
12. The burning of Li, Be, B and the mixing into envelopes.
12.1. G-dwarfs in the galactic disc.
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13. Evolution of the Li, Be, B abundances in the Galaxy.
14. The Li, Be, B synthesis in the standard homogeneous Big Bang model.
15. A possibility of Li, Be, B synthesis for unhomogeneous models.

At the end, several details of making at 6-m telescope of spectroscopy of Li, Be doublets are briefly reported.

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PHYSICAL PARAMETERS AND CHEMICAL COMPOSITION OF COMPONENTS OF THE Am-TYPE BINARY SYSTEM RR LYNCIS

L. S. Lyubimkov, T. M. Rachkovskaya
Crimean Astrophysical Observatory, Crimea, p.Nauchny, 334413, Ukraine

ABSTRACT. On the basis of technique developed earlier we analysed composite spectra of the eclipsing binary RR Lyncis, which has been classified as Am-star. The following values of effective temperature were found: T_{eff}=8020±200 K for the primary component (the star A) and T_{eff}=7150±300 K for the secondary component (the star B). It was shown that the visual magnitude difference between A and B is Δm_v=-1^m.2. Using evolutionary tracks of different authors we determined the mass M of every component; mean values are M_A=1.95±0.06 $M_\odot$ and M_B=1.57±0.07 $M_\odot$. These "evolutionary" masses are in good accordance with M_A and M_B values found by Kondo (1976) from an analysis of the radial velocity curves and the light curves. Both components appear to be on the main sequence and they have the age t=(1.1±0.3)·10^9 years.

Key words: Stars: Binaries, Chemical Compositions

Individual chemical composition of the components was studied; we concluded that it is peculiar for each of them. The component A displays typical features of Am-stars. Here many chemical elements show overabundance, which has a tendency to increase with atomic number Z. For the component B most of elements is in deficiency, but the trend of chemical anomalies with Z are evident, too. There is the systematic discrepancy in element abundances between B and A, which is equal to -0.6 dex on the average.

For comparison the "middle" chemical composition of RR Lyn was determined by the assumption that a single star is observed. On the whole it appears to be closer to the composition of primary component, nevertheless "middle" abundances are lovered by two times on the average relatively this component.

More detailed version of this work was published elsewhere (Lyubimkov & Rachkovskaya 1993).

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CHEMICAL COMPOSITION OF COOL GIANT STARS

N. S. Komarov, N. J. Basak, T. I . Gorbaneva, L. E. Kantsen
Astronomical Observatory, Odessa State University,
T.G.Shevchenko Park, Odessa 270014 Ukraine
E-mail: root@astro.odessa.ua

ABSTRACT. Based upon the catalogue of equivalent widths of absorption lines in spectra of cool giant - stars created at the Astrospectroscopy Aepartment of the Astronomical Observatory in Odessa the abundances in their atmospheres is determined. This determination was made by using the method of model atmospheres. Fundamental characterictics of stars are determined by an independent method by using photometric observations.

Key words: Stars: abundances, giant

The chemical composition in the atmospheres of stars and interstellar medium is needed for testing nucleosynthesis theories and stellar evolution theories.It is necessary to obtain these data for a great number of objects as only in this case one can reliably judge the abundances of light elements, elements of CNO-group, those of iron type and elements of α , r, s - processes.An attempt has been made by use of creating a catalogue of equivalent widths of absorption lines in spectra of cool stars on the basis of literature sources. Spectral material with high resolution is used. The catalogue examination has shown that there is relationely only a few number of stars whose spectra were relationly obtained by different authors. In addition, for common stars there is a little quantity of common absorption lines for iron peak elements. Therefore, at the first stage of investigation the material was reduced by a unified procedure by using model atmospheres and common input data on radiation atomic constants such as the wavelength, oscillator's strength, energies of lower and higher levels. In the given work, a list of absorption lines from the work Kurucz & Peytremann (1975) has been used.

In order to avoid the blending of atomic lines by molecular absorption lines, the giant-stars in the G8 - K3 spectral range have been chosen.

Fundamental characteristics were used according to the method Korotina et al. (1988), Korotina et al. (1989), Korotina & Komarov (1992) by using corresponding photometric indices.

In Table 1 are given values of [A/Fe] averaged from G8, K0, K2, K3 spectral types, and N is the number of stars.

In Table 2 are summarized characteristics of the investigated stars in which a star number, a spectral type Sp, effective temperature T_{eff} gravity lg g, metallicity [Fe/H] from Korotina et al. (1988), Korotina et al. (1989), Korotina & Komarov (1992), Motrich (1990), metallicity [Fe/H] determined in this work, are given.

As is shown in work Korotina et al.(1989), the prevalence of metallic- poor stars is characteristics of G8-K0 spectral types, as to stars of K2-K5 spectral types, it being vice versa. The photometric metallicity index comprises many chemical elements and even molecular bands, therefore it is undoubtedly of interest to check the average abundance of different chemical elements in these or those spectral types.

It is early to draw ultimate conclusions because of a few number of stars studied but one can notice a constant sodium excess tending to enhance from G8 to K3. It should be noted that many elements show discrepancies in abundances determined from absorption lines of atoms and ions.

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Table 1. Abundances in the atmospheres of the stars

El.	G8	N	KO	N	K2	N	K3	N
Li I	-0.06	1	0.09	1	-	-	-0.39	1
C I	-	-	-	-	-	-	2.11	1
Na I	0.40	6	0.41	6	0.76	2	0.75	2
Al I	0.07	1	0.14	2	1.80	1	0.67	2
Si I	0.35	6	0.36	6	0.14	2	0.63	3
Si II	0.78	4	1.24	5	1.99	1	1.37	1
S I	1.24	5	1.27	5	1.87	1	0.97	1
Ca I	0.19	6	0.20	6	0.49	2	0.27	3
Sc I	-0.02	6	0.12	6	0.50	2	0.63	3
Sc II	0.28	6	0.16	6	0.44	1	-0.13	3
Ti I	0.19	6	0.23	6	0.40	2	0.34	3
Ti II	0.23	6	0.14	5	0.31	2	0.04	2
V I	0.15	6	0.26	6	0.68	2	0.42	3
V II	2.35	4	1.90	4	-	-	1.74	1
Cr I	0.03	6	0.03	6	0.36	2	0.21	3
Cr II	0.29	6	0.23	6	0.22	2	0.44	3
Mn I	0.50	6	0.58	6	0.71	2	0.68	3
Mn II	-	-	-	-	-	-	3.54	3
Fe I	0.00	6	0.00	6	0.00	2	0.00	3
Fe II	0.22	6	0.25	6	0.39	2	0.08	2
Co I	0.19	6	0.21	6	0.32	2	0.43	3
Ni I	0.05	6	0.13	6	0.24	2	0.05	3
Cu I	0.78	5	0.96	2	0.19	2	-	-
Zn I	0.80	3	0.79	2	0.24	1	1.12	2
Sr I	1.40	1	0.97	3	0.73	1	0.73	3
Y I	1.21	5	0.96	4	-	-	1.48	2
Y II	0.01	5	0.17	4	-0.09	1	0.16	1
Zr I	0.05	5	-0.21	6	0.17	1	0.75	3
Zr II	0.38	1	-	-	-	-	-	-
Mo I	0.46	5	0.43	4	-	-	0.90	1
Ba I	-	-	0.85	1	-	-	-	-
Ba II	0.23	5	0.17	6	0.07	2	-0.77	2
La II	0.57	6	0.55	6	1.18	1	1.35	2
Ce II	0.13	5	0.31	4	-	-	0.07	2
Pr II	1.28	5	1.46	3	-	-	1.56	1
Nd II	0.45	5	0.39	4	-	-	0.48	1
Eu II	0.78	1	0.52	2	-	-	0.13	1

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Table 2. Characteristics of the stars

*	Sp	T_{eff}	lg g	$[Fe/H]^{Ph}$	$[Fe/H]^{Sp}$
HD 6497	K2 III	4610	2.00	-0.02	-0.74
HD 35620	K3 III	4250	1.60	0.07	-0.22
HD 37160	G8 III	4770	2.60	-0.61	-0.87
HD 43039	G8 III	4720	2.50	-0.42	-0.33
HD 49009	K2 III	4480	2.10	-0.04	-0.68
HD 68879	G8 III	4450	2.20	-0.41	-0.76
HD 95272	K0 III	4780	2.40	-0.12	-0.21
HD 95689	K0 III	4840	2.50	-0.13	-0.15
HD 107328	K1 III	4490	2.10	-0.23	-0.64
HD 129312	G8 III	5060	2.60	-0.14	-0.06
HD 135722	G8 III	4810	2.60	-0.48	-0.69
HD 148856	G8 III	4970	2.80	-0.30	-0.24
HD 188056	K3 III	4690	1.90	0.39	0.02
HD 197989	K0 III	4780	2.50	-0.28	-0.20
NGC 752 N213	K0 III	4730	2.30	-0.04	-0.76
HD 2796		5340	2.50	-0.84	-2.38
HD 4306		5390	3.00	-1.17	-2.67
CD -30 298		5260	3.10	-1.21	-2.96
HD 6268		5120	2.80	-0.93	-2.21
BD -18 271		4280	2.00	-1.31	-2.06

ELEMENTAL ABUNDANCES IN THE ATMOSPHERES OF THREE METAL – DEFICIENT GIANTS

T. V. Mishenina[1], V. G. Klochkova[2], V. E. Panchuk[2]
[1] Astronomical Observatory, Odessa State University,
T.G.Shevchenko Park, Odessa 270014 Ukraine
[2] Special Astrophysical Observatory RAS
Nizhniy Arkhyz, Stavropl'skii Kraii, 357147 Russia

ABSTRACT. High dispersion high resolution CCD spectra have been used for the determination of the elemental abundances in three metal-deficient stars. The following results were obtained: 1) an overabundance of O is found; 2) Si, Ca, Ti are overabundant with respect to iron in stars with [Fe/H]= –1.5; 3) halo stars show an underabundance of the odd elements Na and Al relative to the abundance of the even element Mg); 4) Ni and Mn are slightly overdeficient; 5) an underabundance of Cu is found in all three stars ; 6) s-process elements are slightly overabundant.

Key words: stars: metal–deficient giants – stars: abundances – stars: atmospheres – Galaxy(the): evolution of

STARSP - THE COMPLEX OF PROGRAMS FOR ANALYSIS OF THE SPECTRA OF NORMAL STARS.

V. V. Tsymbal
Department of Astronomy, Simpheropol State University, Crimea, Ukraine

ABSTRACT. STARSP is the first version of analogs of part to CCP7 project. This system allows to make all parts of proceeding and interpretation of stellar spectra in the LTE approach. System works at the IBM/PC–AT computers and may be useful for professionals and students.

Key words: Stars: atmospheres, abundances; Methods: numerical

First part of the system modeling of stellar atmospheres.

The user can:

1) Select the model from one of catalog of models. Now in system include two such catalogs: Kurucz (1989) and "Uppsala" catalog, in which the models for lg g=1.5, 2.25, 3.0 were taken from the published grid of Bell et.al. (1976). For lg g=–0.75, 0.0, 0.75 (T_{eff} = 4000 – 6500 K) [A]=+0.5, 0.0, -0.5, –1.0, –2.0, –3.0 models were computed in 1992 by I.F.Bikmaev in Uppsala using MARCS code of Gustafson et al. (1975).

2) Interpolate between the models from these catalogs.

3) Calculate models atmospheres with using of modified "Atlas–6" program. For cool stars models include molecular absorbtion in "smeared lines" approach from program of T.Kipper and J.Sitska.

Second part is calculation of synthetics spectra. Now in system using two lines list from (3200–9000) Å: Kurucz's (1988) list and compilation from Bell's light and heavy lists with Kurucz's (1991) Fe–Ni list. The computed spectra can be convoluted with a gaussian.

Next part is proceeding of observed spectra with using of previously calculated synthetic spectrum. This part includes:

1) Computation of the dispersion curve and comparison of the observed spectrum with theoretical one.

2) Search of the continuum spectrum level with recommendations from the synthetic spectrum.

3) Determination of the equivalents widths, FWHM and r by using both manual and automatic regimes. Separation of the blends by using the algorithm by V.Kutcherov.

And last part is the abundance determination by using the modified WIDTH6 program by R.L.Kurucz.

All calculations are graphically illustrated. The rule of the system is very simplicity.

Requirements: MS–DOS operating system, about 550 KB conventional memory and 10 MB on hard disk; EGA/VGA monitor. The coprocessor is optional.

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ABUNDANCES OF HELIUM AND OTHER ELEMENTS IN ATMOSPHERES OF CLASSICAL CEPHEIDS

V. V. Kovtyukh, N. S. Komarov, E. A. Depenchuk
Astronomical Observatory, Odessa State University,
T.G.Shevchenko Park, Odessa 270014 Ukraine
E–mail: root@astro.odessa.ua

ABSTRACT. The chemical composition of three classical cepheids δ Cep, η Aql and ζ Gem, has been investigated by using model atmospheres' method. It is shown that Na and Mg are overabundant ($\approx$+0.35 dex), C and O are slightly underabundant ($\approx$ –0.20 dex) relative to the Sun. The atmospheric abundances for other elements are close to the solar composition. The low limit of helium atmospheric abundance in classical cepheids, derived from the spectrum of a physical companion of δ Cep (δ Cep–C, B7 IV, T_{eff}=13250 K, log g=3.85, V_t=0.0 km/s), is [He/H]=–0.13. The comparison of chemical composition in the atmospheres of δ Cep cepheid and its companion obviously illustrates the variation in abundance of CNO elements during the cepheid evolution. If the primary C, O abundance for cepheid is solar–like (as the chemical composition of a companion corresponds to initial composition of the cepheid), then after red–supergiant phase (phase of dredge–up) we can observe the cepheid as a star being deficient in C and O.

Key words: Stars: abundances, Cepheids

For most pulsating stars located in the Hertzsprung–Russel diagram in the instability strip, the zone of critical He II ionization is a principal source of oscillations.Efficiency of this zone is determined by helium abundance. So, according to Cox's (1973) estimation for an autooscillating process, helium abundance $\log\epsilon(He) > 10.70$ (in the scale $\log\epsilon$(H)=12.00) is needed. Due to large potentials of He I excited levels and due to relatively low temperatures in the atmospheres of pulsating stars there are no He I absorption lines in their spectra and that does not permit to reliably assess this element abundance. An approximate estimation was first obtained by Wallerstein (1959) and Raga & Wallerstein (1989) from He I λ5876 Åemission line arising behind the shock wave front. For W Vir (a cepheid of Galaxy halo population), the obtained helium abundance ranges from log ϵ(He)=11.00–11.52. For a classical cepheid, ζ Gem, Shanin & Shcherbakov (1975) have shown the presence of He I λ10830 Å chromospheric line in the spectrum. It is obvious that the question on helium abundance cannot be considered as having been solved.

At the same time a prototype of classical cepheids δ Cep is known to be a visual binary system (ADS 15987) and its component of B7 IV type (δ Cep–C=HD 213307, V=6.31^m) can be quite used for the determination of He abundance. Vitrichenko & Tsarevsky (1969) give convincing arguments for physical correlation between both components (similarity of radial velocities, proper motions and excesses of colour indices). Large remoteness of the system components from each other (ρ=41") guarantees the absence of matter exchange between the components, whereas a common origin is responsible for similarity of the initial chemical composition in the atmospheres of both components. For confirming this likeness, the chemical composition of δ Cep–A itself has been also investigated as well as that of two typical classical cepheids – η Aql and ζ Gem.

Spectrograms have been obtained on the II camera of Main Stellar Spectrograph on 6–m telescope of Special Astrophysical Observatory for the δ Cep–C companion with a reciprocal dispersion of 9 Å/mm for the wavelength

Table 1. Basic data for investigated stars.

Name	Period	Phase	Sp	$(B-V)_0$	$(R-I)_0$
δ Cep–C	–	–	B7IV	–0.113	–
δ Cep–A	5.366^d	0.334^p	F5Ib–G5Ib	0.630	0.315
η Aql	7.177	0.602	F6Ib–G4Ib	0.830	0.430
ζ Gem	10.151	0.364	F7Ib–G3Ib	0.885	0.420

Table 2. Atmospheric parameters for the program stars.

Star	T_{eff} (K)	log g	V_t (km/s)
δ Cep–C	13250	3.85	0.0
δ Cep–A	5800	1.5	3.8
η Aql	5600	1.6	4.2
ζ Gem	5700	1.4	3.7

Table 3. Equivalent widths of HeI lines for δ Cep–C.

λ (Å)	W_λ	λ (Å)	W_λ
3964.73	152	4437.55	67
4026.18	502	4471.47	410
4120.81	50	4713.14	166
4387.93	178		

range from $\lambda\lambda$ 3900–4900 Å (Kodak IIaO) and for δ Cep, η Aql and ζ Gem with a reciprocal dispersion of 14 Å/mm for the wavelength range from $\lambda\lambda$ 5100–6800 Å (Kodak 103aF). The basic data for stars are given in Table 1.

The spectrogram reduction was carried out by using a standard method: a continuous spectrum was plotted from intensity peaks, equivalent widths W_λ were calculated in triangular approximation; for blended lines the equivalent widths were determined from the relation $W_\lambda = f(R_\lambda)$, where R_λ is the residual intensity in the center of an absorption line.

The atmosphere parameters of δ Cep–C (T_{eff}, log g) were determined from comparison of the observed profiles of hydrogen lines Hγ ,Hδ with a grid of theoretical ones calculated by Kurucz (1979). For determination of T_{eff} –value for classical cepheids, Hα profiles were used as well as color indices of $(B-V)_0$ and $(R-I)_0$. Color indices for a corresponding phase were found from observations of Moffett & Barnes (1984), calibrations of $(B-V)_0 \approx T_{eff}$ and $(R-I)_0 \approx T_{eff}$ by Bell & Gustafsson (1978) and Schmidt (1973) respectively were used, whereas color excesses were calculated by using a relation of period–intrinsic color obtained by Dean et al. (1977). The gravity value log g was determined provided there was ionization equilibrium for Fe, Ti, V, Cr elements. Microturbulent velocity V_t was estimated by requiring for derived Fe I abundances to be independent of equivalent widths of Fe I lines. Final parameters of models T_{eff}, log g, V_t are given in Table 2. The probable errors in parameters determination amount to ± 200 K in T_{eff}, ± 0.3 in log g and ± 0.5 km/s in V_t. These uncertainties in adopted parameters produce corresponding variations in abundances: ± 0.14 dex, ± 0.02 dex and ± 0.04 dex respectively (for neutral atoms).

For the δ Cep–C, the helium abundance has been determined by using curves of growth grid (dependencies of W_λ (He I) on T_{eff}, log g and [He/H]) which were calculated by Tsymbal (1990) in NLTE approximation. It was taken into account that HeI lines are blended by those of other elements. The W_λ values of helium lines for δ Cep–C are presented in Table 3. These values have been compared with the average W_λ values for stars of B7 IV type (obtained by Klochkova & Panchuk (1987)). It was derived that W_λ values for δ Cep–C are nearly 27% less than the average value for the stars of similar spectral type. This circumstance confirms the slight deficiency of He relative to the Sun.

The analysis of abundance for other chemical elements in the atmospheres of the investigated stars was done by using WIDTH–6 code (Kurucz 1979). Oscillators' strengths were taken from works by Thevenin (1989, 1990). In

Table 4. Chemical abundances.

Element	δ Cep–C	δ Cep–A	η Aql	ζ Gem
He I	–0.13 (7)	–	–	–
C I	–	–0.46 (2)	–	–0.10 (2)
C II	–0.08 (1)	–	–	–
O I	–0.06 (1)	–0.20 (2)	–0.35 (1)	–0.22 (2)
Na I	–	+0.20 (3)	+0.10 (4)	+0.33 (2)
Mg I	–	+0.19 (2)	+0.09 (2)	+0.56 (3)
Mg II	+0.20 (1)	–	–	–
Si I	–	+0.07 (14)	+0.28 (14)	+0.08 (20)
Si II	+0.12 (3)	+0.07 (2)	+0.35 (2)	+0.31 (1)
S I	–	–0.24 (2)	–0.23 (2)	+0.28 (2)
S II	+0.09 (2)	–	–	–
Ca I	–	+0.09 (7)	–0.15 (17)	+0.02 (22)
Ca II	+0.10 (2)	–	–	–
Sc II	–	+0.08 (9)	–0.11 (11)	+0.07 (12)
Ti I	–	+0.06 (9)	+0.36 (34)	+0.19 (25)
Ti II	+0.04 (3)	+0.05 (3)	+0.22 (5)	+0.06 (7)
V I	–	+0.08 (10)	+0.15 (29)	+0.40 (32)
V II	–	+0.11 (4)	+0.01 (7)	+0.26 (9)
Cr I	–	–0.11 (7)	–0.17 (8)	+0.13 (15)
Cr II	–	–0.06 (5)	+0.09 (3)	+0.12 (9)
Mn I	–	+0.05 (11)	+0.40 (10)	+0.15 (12)
Fe I	–	–0.03 (62)	+0.07 (71)	+0.17 (83)
Fe II	–0.11 (19)	–0.07 (8)	+0.04 (15)	+0.14 (25)
Co I	–	+0.01 (9)	+0.23 (7)	+0.38 (12)
Ni I	–	–0.05 (14)	+0.06 (12)	–0.05 (38)
Sr II	+0.36 (2)	–	–	–
Y II	–	–0.01 (4)	+0.23 (7)	+0.10 (14)
Zr II	–	+0.09 (2)	–	+0.02 (2)
Ba II	–	+0.21 (2)	+0.25 (1)	+0.06 (1)
La II	–	+0.45 (4)	+0.28 (5)	+0.01 (5)
Ce II	–	+0.02 (6)	+0.31 (5)	–0.13 (5)
Pr II	–	–	+0.14 (2)	+0.11 (2)
Nd II	–	+0.16 (7)	+0.35 (5)	+0.02 (9)
Eu II	–	+0.29 (2)	+0.32 (1)	+0.01 (1)

order to exclude accidental errors in comparing elemental abundancies in the atmosphere of the stars under study with the solar one, the chemical composition of the Sun's atmosphere found by these oscillator strengths was also taken from the work by Thevenin (1989).

The results of our determination are given in Table 4. The number of lines used is shown in brackets. For cepheids, slight Na, Mg excess and C, O deficiency have been obtained. For all the rest elements the chemical composition is similar to that of the Sun within the limits of determination errors. This confirms conclusions drawn earlier by other authors: Luck & Lambert (1981), Klochkova (1991) et al. In the work by Klochkova (1991), one can also find conventional explanations of the noted deviations of these objects' abundance from the solar one, in particular, C and O deficiency is accounted for dredging up matter processed in CNO–cycle reactions.The comparison of chemical composition in the atmospheres of δ Cep cepheid and its companion obviously illustrates the variation in abundance of CNO elements during the cepheid evolution. If the primary C,O abundance for cepheid is solar–like (as the chemical composition of a companion corresponds to initial composition of the cepheid), then after red–supergiant phase (phase of dredge–up) we can observe the cepheid as a star being deficient in C and O.

The analysis of the results shows that chemical composition of δ Cep–A and C is consistent (except for C, O) within the limits of determination errors and is typical of classical cepheids. A possible duplicity of δ Cep–C discussed by Vitrichenko & Tsarevsky (1969) does not affect the results obtained. Hence, one can estimate a lower limit of He abundance for classical cepheids $\log \epsilon(\mathrm{He})=10.87$ or -0.13 dex relative to that in the solar atmosphere.

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Table 1 (to the paper by Shavrina et al., page 151)

Star	Sp	[C]		[N]		[O]
		CI	CH	CN	NH	[OI]
γ 1 Leo	K0 III	+0.46	+0.47	0.00	+0.28	+0.62
γ 2 Leo	G8 III	-0.16	—	+0.20	—	+0.50
β Gem	K0 III	-0.19	-0.16	+0.50	+0.28	-0.18
α Ser	K2 III	+0.09	+0.09	—	+0.23	+0.16

C,N,O ABUNDANCES IN THE ATMOSPHERES OF FOUR LATE GIANT STARS

A. V. Shavrina[1], L. A. Yakovina[1], M. E. Boyarchuk[2], I. F. Bikmaev[3]
[1] Main Astronomical Observatory, Academy of Sciences of Ukraine
Goloseevo, Kiev 252127 Ukraine, E-mail: mars@gao.kiev.ua
[2] Astronomical Institute, Russian Academy of Sciences, Moscow
[3] Special Astrophysical Observatory, Russian Academy of Sciences, Nizhniy Arkhyz

ABSTRACT. The abundance of C,N,O have been determined for 4 late giant stars from atomic and molecular spectra by the method of synthetic spectrum.

Key words: Stars: Atmospheres, late-type giants, chemical composition

The important task in the astrophysics is the light elements abundance analysis for the stellar atmospheres, especially for the late-type giant atmospheres undergone the first "dredge-up". In this work we have determined C,N,O abundance in atmospheres of four late-type giants.

Usually the abundance of oxygen is determined using the profiles of [OI] lines in the red spectral region. Frequently the carbon and on the most nitrogen atomic lines can not be used for abundance analyses because they are not observed in the late-type stars spectra. Among molecules containing carbon and nitrogen the hydrides NH and CH are preferable because they give a possibility to determine the ratio N/H and C/H directly. If the abundance of CH molecule depend on the ratio O/C in the late-type atmospheres, the abundance of NH molecule does not depend on this ratio.

The spectrograms of four K-giants (see Table 1, page 150) in blue and red regions with dispersion 4 and 6 A/mm were obtained on 2.6 m telescope (Crimea). The ultraviolet spectrograms of three stars (except γ 2 Leo) with dispersion 14 Å/mm were obtained on 6m telescope (Northern Caucasus).

We estimated the nitrogen abundance from the NH bands in the region 3350 - 3370 Å for three K-giants - β Gem (K0III), γ 1 Leo (K0III), α Ser (K2III) - using spectrograms with dispersion 14 Å/mm. In synthetic spectra calculations the line absorption coefficient included atomic lines and molecular lines of NH and OH.

We also estimated nitrogen abundance for 3 K-giants - β Gem, γ 1 Leo, γ 2 Leo - using CN-blue ($\approx$ 4200 Å) molecular band 0-0. (Earlier we have determined the ratio O/C for this stars from CI and [OI] lines). In the spectra of α Ser CN-band is too strong to be analyzed.

The carbon abundance was also estimated from CH band ($\approx$3889 Å) with previously determined oxygen abundance. We note that this band is very sensitive to carbon abundance for our stars.

Table 1 represents the abundance of C,N,O determined for 4 late giant stars by the method of synthetic spectra from atomic and molecular spectra. The models of atmospheres γ 1 Leo, γ 2 Leo and β Gem were taken from Bell et al. (1976). The model atmosphere for α Ser was calculated using the program SAM1C (see Kipper & Sitska 1981).

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THE ABUNDANCES IN THE STELLAR ATMOSPHERES IN THE M13 GLOBULAR CLUSTER

T. V. Mishenina, S. V. Kutsenko
Astronomical Observatory, Odessa State University,
T.G.Shevchenko Park, Odessa 270014 Ukraine

ABSTRACT.The chemical composition of 5 stars' atmospheres in globular cluster M13 and 2 halo stars taken from literature have been computed. A slight excess of O and deficit of Mg have been defined for globular cluster stars. The elements Si,Ca,Ti are overabundant (≈ 0.3 dex), Ni is slightly deficient (–0.08), Mg – more deficient (–0.3), Y – slightly overabundant. Comparison with halo stars showed the difference in composition of Na, Mg and elements of r–, s– processes.

Key words: globular cluster, stars, chemical composition.

1. Introduction

Still at earlier stages of photometric investigations of stars in the globular clusters, a difference in intensity bands of CO and CN for the stars with close temperatures and luminosities (in the same cluster) was noted. For example, stars in the globular cluster, ω Cen, are distinctly disintegrated into two sequences of CN–strong and CN–weak stars (Francois et al. 1988); differences in intensities of CN bands are observed for M13 (Lehnert et al. 1990) etc. Spectral investigations of stars have shown differences in abundances of O,Na,Al, anticorrelation between the O abundance and that of the Na, Al and correlation between the Na,Al abundances and CN intensity bands (Suntseff 1981; Wallerstein et al. 1987).

For the elements of α –process (Mg, Si, Ca, Ti), a greater excess (0.4 dex) has been found relative to iron as compared to the Sun than that in similar halo stars (Gratton and Sneden 1987). Elemental abundances of r–,s– processes are also different from star to star.

The aim of this work is to plot curves of elemental abundances in the stars' atmospheres in the M13 cluster, to analyse dependencies between chemical composition of elements and to compare those with abundance curves for halo–stars.

2. Observational material

As observational data we have used equivalent width of lines measured in spectra of stars from (Cohen 1978; Luck and Bond 1985).

Model parameters of the stars and photometric indices are given in Table 1.

3. The determination of abundances

Elemental abundance in the atmospheres of stars under the study was determined with the computer program WIDTH–6 by Kurucz and adapted for IBM PC by V.V.Tsymbal and Yu.Yavorsky.

For all the elements solar oscillator strength log gf were used from Gurtovenko and Kostyk (1989). Model atmospheres were taken from Bell et al. (1976). Solar elemental abundances were determined in the same system.

In Table 2 are given results of our determinations for 5 stars from the globular cluster M13, 2 similar halo giants and for Sun too.

4. The discussion of results

a) CNO and light metals.

It is of interest to compare the O abundance obtained for the investigated stars with CN intensity bands. Unfortunately, the values of intensity bands are only known for two (I–13 and III–73) out of five stars. They show average CN values (1.32 and 1.296) close to each other and close to O abundance values.

The matter is still worse with Na and Al. There is only "traces" of the Na line in one star, so we can't take advantage of this qualitative estimation. In the work by Wallerstein and Leep (1987), the star III–63, in which we

Table 1. Main characteristics of the stars.

*	T_{eff}	log g	[Fe/H]	v_t	B–V	CN
M13	–	–	–	–	–	–
B–140	4000	0.5	–1.5	2.0	–	–
IY–25	4000	0.5	–1.5	2.2	–	–
I–13	4250	0.9	–1.5	2.0	1.25	1.321
III–63	4200	0.7	–1.5	1.5	–	–
III–73	4300	0.8	–1.5	2.0	1.27	1.296
HD103036	4250	0.8	–1.5	2.0	–	–
HD135248	4250	0.75	–1.8	2.5	–	–

Table 2. Results of determination of abundances [El/H].

El.	B–140	IY–25	I–13	III–63	III–73	103036	135148	Sun
O I	–4.26	–4.88	–4.61	–4.65	–4.67	–4.08	–4.58	–3.31
Mg I	–6.60	–6.59	–6.10	–6.45	–6.24	–5.84	–6.07	–4.49
Si I	–5.91	–5.49	–5.60	–	–5.69	–5.51	–5.67	–4.44
Ca I	–7.13	–7.00	–6.90	–6.90	–7.06	–6.88	–7.22	–5.68
Sc I	–10.62	–10.63	–10.63	–10.38	–10.24	–10.46	–10.29	–9.04
Ti I	–8.23	–8.46	–8.42	–8.20	–8.08	–8.19	–8.65	–7.17
V I	–9.60	–9.62	–9.58	–9.52	–9.42	–9.42	–9.95	–8.21
Cr I	–7.86	–8.18	–8.58	–8.12	–8.04	–7.33	–7.89	–6.25
Mn I	–8.15	–8.24	–8.11	–8.29	–8.29	–8.51	–8.97	–6.35
Fe I	–5.97	–5.66	–5.86	–5.71	–5.63	–5.84	–6.14	–4.40
Co I	–8.45	–8.68	–8.56	–8.60	–8.71	–8.00	–8.22	–7.25
Ni I	–7.26	–7.22	–7.39	–7.16	–7.35	–7.23	–7.78	–5.86
Cu I	–9.74	–9.86	–9.90	–9.93	–9.90	–9.83	–10.34	–7.35
Y II	–11.55	–10.51	–11.10	–	–10.66	–11.00	–	–9.88
Ba II	–11.90	–11.95	–11.22	–11.69	–11.60	–10.86	–11.51	–9.81
Ce II	–11.68	–11.63	–11.68	–11.26	–11.31	–12.11	–	–10.57
Nd II	–12.17	–12.16	–12.15	–12.11	–12.01	–11.68	–	–10.85

take interest, was investigated. For this Al excess has been obtained.

On the average O is slightly overabundant (0.1 dex) and Mg is underabundant (–0.5 dex) in the stars under study. Unfortunately, the results are obtained from one line only.

b) α–elements, Fe–peak, r–,s–processes. As is seen from the abundance curve, α–elements show excess, Co has no variations, Ni is slightly deficient(–0.08), Mn – more deficient. The Y element of s–process (primarily) is slightly overabundant. This elemental distribution is quite consistent with the fact that interstellar medium, from which the investigated stars originated, was enriched in products of Supernova II explosion synthesis.

c) Comparison with the halo stars has shown a difference in abundances of Na, Al, Mg and the elements of r–, s– processes.

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STATISTICAL EQUILIBRIUM OF THE LITHIUM IN DIFFERENT METALLICITY DWARF ATMOSPHERES WITH $T_{eff} = 5770$ K, $\lg g = 4.44$

Ya.V. Pavlenko, L.A. Yakovina
Main Astronomical Observatory, Academy of Sciences of Ukraine
Golosiiv, Kiev 252127, Ukraine
E-mail: yp@mao.gluk.apc.org

ABSTRACT. Results of computations of the lithium statistical equilibrium in atmospheres of $T_{eff} = 6270$, 5770, 5270 and lg $g = 4.44$ dwarfs of metallicities $[\mu] = -0, -1, -2, -3$ are discussed. It is shown that NLTE corrections are less then 0.1 dex for abundances of lithium observed in these stars.

Key words: Stars: atmospheres, lithium abundance, solar – like dwarfs.

Model atmospheres of these stars were computed by SAM1K program (Pavlenko and Yakovina 1994). The blocking effect due to radiation absorption by atom and ion lines was taken into account by opacity sampling method.

The model atom consists of 19 levels of Li I, and the ground state of Li II. Selfconsistent system of statistical equilibrium and the radiative transfer equation were solved by partial linearization method. The blocking effect in the frequencies of bound-free transitions due to radiation absorption by lines of atoms and ions has been taken into account. 70 bound-bound and bound-free transitions were involved into computations.

The collisional excitation rates were computed by formula

$$C(i,j) = Ce(i,j) + Ch(i,j) \cdot q, \quad (1)$$

where Ce and Ch are probabilities of $i \rightarrow j$ transition due to inelastic collisions with free electrons and hydrogen atoms correspondingly. For the time parameter q is poor defined (see Steenbock and Holweger 1984): $0 < q < 1.0$. In this paper we give results obtained for $q = 0$ and $q = 1$.

A comparison of LTE and NLTE equivalent widths for lines of resonance doublet 670.8 nm and subordinate doublet 610.3 nm are given below.

We would like to admit the following results:

a) the sign and values of abundance corrections due to NLTE effects in resonance doublet 670.8 nm depends on model atmosphere structure, transition rates due to inelastic collisions with atomic hydrogen, and the abundance of lithium.

b) for subordinate line 610.3 mn the sign and values of abundance corrections are positive always.

c) in wide range of abundances ($1.0 < \varepsilon(Li) < 3.5$) the Lithium abundance corrections due to NLTE effects are less then 0.1 dex for solar type dwarfs. So the classical results of Spite and Spite (1982) cannot be changed taking into account the NLTE in lithium lines.

d) the dependence of our results on parameter q is not crucial.

e) our computations show that the dependence of NLTE corrections for lithium abundances on the metallicity of solar like stars is rather weak then strong.

To explain latest result we compare the temperature structutes of Z0 and Z3 models. It is well known result, that gradient temperature in the model atmosphere depends from metallicity. In model Z3 that gradient is lowered in comparison with Z0 model. The difference between T_r - radiative (excitation) temperature

Table 1. The ratio W(LTE)/W(NLTE) computed for Li I 670.8 and 610.3 mn lines. W(LTE) and W(NLTE) - equivalent widths of lines computed in LTE and without LTE correspondingly. Abundances of Li are given in the scale where $\varepsilon(H) = 12$. There are results for two model with $T_{eff} = 6270$, $\lg g = 4.44$. One of them (Z0) has solar metallicity, in the second model (Z3) $[\mu] = -3$.

Lines		670.8 nm				610.3 nm			
Model	abund	Z0		Z3		Z0		Z3	
	Lith.	q=0	q=1	q=0	q=1	q=0	q=1	q=0	q=1
	1.00	1.042	.997	1.110	0.939				
$T_{eff} = 6270$,	1.50	1.040	.995	1.105	0.937	1.101	1.055	1.210	1.055
$\lg g = 4.44$	2.00	1.032	.989	1.093	0.931	1.100	1.054	1.211	1.054
	2.50	1.008	.968	1.055	0.910	1.100	1.054	1.211	1.055
	3.00	0.943	.913	0.962	0.854	1.097	1.051	1.209	1.054
	3.50	0.834	.818	0.817	0.758	1.087	1.042	1.198	1.048

Table 2. The W(LTE)/W(NLTE) ratio computed for Li I 670.8 and 610.3 mn lines. Model atmospheres 5270/4.44, metallicities are 0 and -3.

Lines		670.8 nm				610.3 nm			
Model	abund	Z0		Z3		Z0		Z3	
	Lith.	q=0	q=1	q=0	q=1	q=0	q=1	q=0	q=1
T_{eff}=5270,	1.00	1.226	1.137	1.293	0.999	1.199	1.116		
$\lg g = 4.44$	1.50	1.198	1.116	1.269	0.991	1.198	1.116	1.242	1.011
	2.00	1.123	1.056	1.205	0.967	1.196	1.114	1.242	1.011
	2.50	.9817	0.9383	1.072	0.907	1.192	1.111	1.243	1.012
	3.00	.8509	0.8327	0.895	0.819	1.176	1.097	1.236	1.011
	3.50	.8101	0.8092	0.781	0.772	1.126	1.054	1.208	1.000

and T_e in model Z3 is smaller than in model Z0. So the intensity of NLTE effects in model does not increase dramatically despite lower opacities in the frequencies of bound-bound and bound-free Li I transitions.

More details for 5770/4.44 models atmosphere will be given in the paper (Pavlenko 1994). We admit only, that for the Sun abs($\Delta\varepsilon$(Li))$<$ 0.05 dex has been obtained. Semiempirical model atmospheres have shown less pronounced NLTE effects in comparison with theoretical ones. For large abundances of lithium $\varepsilon(Li) >$ 3.2 dex the NLTE effects for resonance lines should be larger: ($\Delta\varepsilon$(Li)< -0.2 dex).

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THE IDENTIFICATION OF ABSORPTION LINES OF DYSPROSIUM IN THE SOLAR SPECTRUM.

A. V. Yushchenko, V. F. Gopka
Astronomical Observatory, Odessa State University,
T.G.Shevchenko Park, Odessa 270014 Ukraine
E-mail: root@astro.odessa.ua

ABSTRACT. 12 additional absorption lines of Dy II were identified on the basis of calculations of synthetic spectrum and it's comparison with the spectral atlas of solar flux.

Key words: atomic data – line identification – Sun: abundances – Sun: photosphere

The information contained in the data on the abundances of r–, s–processes elements can help to check the elements creation theory.

The identification of absorption lines of these elements in the Solar spectrum is necessary for deriving the abundances. The work of Moore et al. (1966) contain 39 unblended and 17 blended lines of Dy II in the solar spectrum from 2935 to 8770 Å. More than 6000 lines in the solar spectrum are marked as unidentified lines in the mentioned paper. Moore et al. (1966) note, that further laboratory work on the lanthanon group of rare earths may add to line identifications in spectra of elements to be present.

The meteoritic abundance of dysprosium is $\lg A(Dy)$=1.15±0.01 in the usual logarithmic scale, where $\lg A(Dy)=\lg(N_{\rm Dy}/N_{\rm H})+12.00$ (Grevesse and Noels, 1993). The abundance of dysprosium in the Solar photosphere is $\lg A(Dy)$=1.1±0.15 (Anders and Grevesse, 1989). Recently Grevesse et al. (1993) and Biemont and Lowe (1993) derived abundance of disprosium in the solar photosphere: $\lg A(Dy)$=1.14±0.08 (20 lines) and $\lg A(Dy)$=1.20±0.06 (16 lines) respectively. Grevesse et al. (1993) identified 2 lines of Dy II (λ 3914.868 Å and λ 4011.294 Å) and used 18 lines identified by Moore et al. (1966). Biemont and Lowe (1993) identified 2 lines of Dy II (λ 4011.288 Å and λ 4041.975 Å). The rest of lines used by these authors were identified by Moore et al. (1966).

The aim of this paper is a search for additional absorption lines of disprosium in the Solar spectrum.

For a more complete investigation of abundances of heavy elements the synthetic spectra were calculated for Sun within the wavelength range of 2990 – 7470 Å with interval of 0.01 Å .

Theoretical spectrum was calculated using Tsymbal (1992), Pavlenko (1994) and last version of Gadun and Sheminova (1988) programs. These programs are based on Kurucz's ATLAS6 program.

The used line list include one of the versions of Kurucz's computations for iron group elements (1991) and files NBSDATA, NLTELINES, BELLLIGHT, BELLHEAVY (Kurucz, 1992, 1993). Molecular lines have not been considered.

This synthetic spectrum was used only for identification: from calculations the unblended and faintly blended absorption lines of disprosium were selected. Each line selected from the computed list was investigated in the observed spectrum. Spectral atlas of solar flux was used (Kurucz et al., 1984).

12 additional absorption lines of Dy II were identified on the basis of calculations of synthetic spectra and their comparison with the spectral atlases of Sun.

Selected lines of dysprosium were analyzed by the method of spectrum synthesis or model atmospheres.

The method of spectrum synthesis was used

Table 1. Lines of dysprosium in the Solar spectrum

	Moore et al.(1966)					
λ (Å)	λ (Å)	Ident.	W (mÅ)	W (mÅ)	lg *gf*	lg *A*
3171.466	.466	no id.	12.0		−0.02	1.29
3305.400	.414	no id.	7.0		0.53	1.26
3305.512	.512	no id.	8.0		0.60	1.27
3539.369	.361	Fe I	3.0		−0.57	1.24
3544.347	.347	no id.	2.5		0.00	0.88
3620.161	.156	no id.	6.5	3.0	0.39	0.99
3629.416				6.7	0.63	1.08
3782.871				1.3	−1.03	1.13
3957.790	.797	no id.	4.5	4.7	0.08	1.12
3991.316	.314	no id.	9.0	6.0	0.08	1.40
4091.757				1.2	−0.22	1.31
4124.627	.630	no id.	5.5	2.7	−0.44	1.14

for first five lines in the wavelength region 2960 – 3600 Å. The unidentified lines were replaced by artificial lines of Fe I. Synthetic spectra were broadened by Gaussian type macroturbulence with velocity 1.6 km/s and rotation (2 km/s).

The rest of lines were analyzed by the model atmospheres method. The equivalent widths of these lines were determined using the methodic of decomposition of the spectrum into gaussians (Kassatella, 1976).

Holweger and Muller (1974) solar model were used for determination of dysprosium abundance in the Sun atmosphere. Microturbulent velocity (0.9 km/s) were derived by Gopka and Yushchenko (1994). For model atmosphere method calculations we used Kurucz's program WIDTH9.

One of the most important problems for obtaining the abundance of dysprosium in the solar atmosphere is oscillator strengths. In this paper we use Kurucz's (1992,1993) oscillator strengths from file BELLHEAVY.

Table 1 contains the identifications of dysprosium lines in the solar spectrum. The wavelengths are given in the first column, last figures of wavelengths, identifications and equivalent widths from Moore et al. (1966) are given in the next three columns. Equivalent widths derived from Solar flux atlas (Kurucz et al., 1984), oscillator strengths and logarithmic abundances are given in the last three columns.

Twelve additional lines of disprosium are identified in the Solar spectrum. These lines will be used for determination of dysprosium abundance in the Solar photosphere.

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THE ABUNDANCES OF SOME HEAVY ELEMENTS IN THE ATMOSPHERE OF γ TAURI

A. V. Yushchenko, V. F. Gopka
Astronomical Observatory, Odessa State University,
T.G.Shevchenko Park, Odessa 270014 Ukraine
E-mail: root@astro.odessa.ua

ABSTRACT. Comparison of synthetic spectrum of the γ Tauri photosphere and high quality spectral atlases of this star permit us to identify absorption lines of rubidium, indium, disprosium, erbium, osmium in the observed spectra. The abundances of these elements in the atmosphere of γ Tauri with respect to their abundances in the solar atmosphere were determined by the method of spectrum synthesis.

Key words: $r-, s-$processes elements – stellar abundances

The investigations of abundances of $r-$, $s-$processes elements in the atmospheres of stars of different types are important for solving a number of astrophysical problems. The present study is aimed at the determination of the abundance of some heavy elements in the photosphere of γ Tauri.

γ Tauri is a member of Hyades cluster. This is the nearest cluster to the Sun. In time it is only one-tenth. the age of the Sun so its overall chemical abundance will provide evidence of any general enrichment that the Galaxy may have received in heavy elements since the birth of the Sun (Griffin and Holweger, 1989). A high resolution spectral atlases of this star were published by Gratton et al. (1975) and Appelquist et al. (1983). The wavelength regions of these atlases are 3985–4812 Å and 5186–8693 Å, respectively.

The synthetic spectra were calculated for K0 III type star and for solar type star within the wavelength range of spectral atlases of γ Tauri with interval of 0.01 Å. Tsymbal (1992) and Gadun and Sheminova (1988) programs were used. The used line list consists of one of the versions of Kurucz's computations for iron group elements (1991) and files BELLLIGHT, BELLHEAVY, NBSDATA, NLTELINES (Kurucz, 1992, 1993).

We used the following parameters of the atmosphere models: $T_{\rm eff}$=5000 K, $\lg g$=2.7, $v_{\rm micro}$=1.6 km/s for γ Tauri, $T_{\rm eff}$=5777 K, $\lg g$=4.4377, $v_{\rm micro}$=0.9 km/s for Sun. Kurucz (1992) grid of atmosphere models were used. The synthetic spectrum of K0 III type star in the wide spectral region was used only for iden-

Table 1. Abundances of heavy elements in the atmosphere of γ Tauri

							Moore et al.,1966	
Z	Ident.	λ (Å)	lg gf	$\lg A_\gamma$	$\lg A_{\rm Sun}$	$\Delta \lg A$	λ (Å)	Ident.
37	Rb I	7800.26	+0.14	2.39	2.38	+0.01	7800.290	Rb I
49	In I	4511.31	−0.21	1.42	1.51	−0.09	4511.310	In I
66	Dy II	4073.12	+0.10	0.70	0.93	−0.23	4073.125	Dy II
68	Er II	4048.34	−0.57	0.99	1.10	−0.11		
76	Os II	4420.47	−1.53	1.39	1.27	+0.12	4420.460	Os II

tification: the unblended and faintly blended absorption lines of heavy elements, which were not investigated in the atmosphere of γ Tauri earlier, were selected from calculations. Each line selected from the computed list was investigated in the observed spectrum. For these purposes we developed a software for displaying on the screen of IBM PC the observed and synthetic spectra simultaneously, in any desired scale. In such a way the possibility of errors in identification has been forced to zero.

Selected lines were analyzed by the method of spectrum synthesis. The unidentified lines were replaced by artificial lines of iron. Synthetic spectra were broadened by Gaussian type macroturbulence with velocity 4 km/s for γ Tauri or 1.6 km/s for Sun and rotation with velocity 2 km/s for Sun. Kurucz et al. (1984) spectral atlas of solar flux were used. Effects of rotation are not fully taken in account for γ Tauri. Instrumental profile was assumed to be Caussian for γ Tauri.

Results of our work are shown in Table 1: charge of nuclei, identification, wavelength, lg gf, abundance of element in the γ Tauri and solar atmospheres (in the scale $\lg A(H)$=12.00), abundance of element in the atmosphere of γ Tauri with respect to the solar one. In the last columns of Table 1 wavelength and identification from the solar spectrum by Moore et al. (1966) are shown.

The abundances of rubidium, indium, dysprosium, erbium, osmium in the atmosphere of γ Tauri are solar (in the range of errors).

Observations of γ Tauri with better signal to noise ratio and high spectral resolution are desired to obtain a more precise result.

Acknowledgement. This work was supported in part by State Committee on Science and Technology of Ukraine (grant 6.3/328) and ESO C&EE Programme (grant A–06–031).

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POLARIMETRIC INVESTIGATION OF BL LAC.

V. A. Hagen-Thorn, V. A. Yakovleva
Department of Astronomy, St.-Petersburg State University
Bibliotechnaja Pl.2, St.-Petersburg, Petrodvoretz, 198904, Russia
E-mail: vayak@astro.lgu.spb.su

ABSTRACT. The extensive homogeneous set of polarimetric observations of BL Lac (1969-1991) has been obtained at Astronomical Observatory of St.-Petersburg University. We discuss the general polarization behavior of the object. The existence of the preferable direction of polarization (in the range between 20 and 30 degrees) as well as the dependencies between polarization parameters and between the polarization and brightness is found. In the individual sources responsible for variability the degree of polarization is as high as 50synchrotron nature of these sources is undoubted.

Key words: BL Lac

The problem of the activity of the extragalactic objects is one of the main problems of current astrophysics. Many extragalactic objects demonstrate the activity of different levels, but blazars are the most active. They show the high variable polarization and the strong rapid photometric variability in the optical region. BL Lac is one of the most studied object of that type, but the details of its behavior on long time scales are not quite clear.

In this paper we discuss the results of the polarimetric observations of BL Lac obtained at Astronomical Observatory of St.–Petersburg University in 1969–1991 (Hagen–Thorn et al. 1984, Hagen–Thorn et al. in press). These observations were carried out with the 48–cm reflector. Because of the small aperture the duration of one polarimetric observation was 1.0–1.5 hours.The comparison of our results with those obtained with the large telescopes shows a good agreement (Hagen–Thorn et al. 1984).

The behavior of the polarization parameters is different for different time ranges. Sometimes the parameters of polarization are constant during the month (for example, October 1983, September 1989, August 1989), but sometimes they are variable within a day. A strong variability of polarization on the time scales of an hour was observed only once (6/7 October 1978).

According Angel & Stockman (1980) there are two groups of blazars: the first one with the preferable direction of polarization and the second one without this. But we feel that the conclusion about absence of the preferable direction for some lacertids may arise from the lack of observational data. For example, in the case of BL Lac those authors pointed out that there is "no tendency for preferable angle" but our extensive observations show undoubtedly that the preferable direction exists (Hagen–Thorn et al. 1985, Hagen–Thorn et al. in press).

It has been found that only a weak correlation exists between the degree of polarization and brightness, but the polarization angle shows the dependence on the brightness: for the low brightnesses only directions near to preferable one exist (Hagen–Thorn et al., 1986). This fact is in agreement with the idea of the existence of constantly acting polarized source in blazars; its polarization angle defines the preferable direction (Hagen–Thorn, 1980).

Clearing up of the origin of variable sources is of great importance. In (Hagen–Thorn,1981) the method was proposed of extracting of the sources of polarized radiation. The application of this method to BL Lac shows that the polarization degree in some sources is as high as 50is the only possible explanation of so high polarization. The colorimetric data also give arguments for synchrotron origin of variable sources.

Since the radiation of polarized sources is synchrotron in nature, the existence of preferable direction of polarization (determined by magnetic field direction) is the indication of stable magnetic fields in blazars.

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THE EFFECTIVE TEMPERATURE DETERMINATION OF O-B STARS BY H AND He RADIO RECOMBINATION LINES OBSERVATIONS

A. P. Tsivilev,

P. N. Lebedev Physical Institute, RAS FIAN Puschino Moscow Region 142292 Russia

E-mail: tsivilev@rasfian.serpukhov.su

ABSTRACT. It is proposed to evaluate, on the basis of H and He radio recombination line observations, the number ratio of stellar photons, capable to ionize helium, to those capable to ionize hydrogen. Then, comparing this ratio with a prediction of model stellar atmospheres, the effective temperature and other stellar parameters are determined. Thus to the information about a total number of Ly–c quanta it adds the information about a spectrum slope in Ly–c wavelength range, which is not directly observable, but information about it is special importance for O–B stars. The choice of an object and angular radio telescope resolution needs to make so that ionizing photons (Ly–c) should be absorbed completely in a region of investigation and beam should cover enough this region. Therefore it is proposed to use compact HII regions and a central part (core) of such HII regions which have a "blister"-type structure. This way is applied to the galactic HII regions: Orion A (38500), DR-21 (36000), S106 (35300), Sgr B2(N3) (35100), W48 (38700), Orion B (36100), W3A (43000), there the obtained effective temperature of exciting stars are in parentheses. Results of it are discussed and compared with different model stellar atmospheres. For sources S106 and Sgr B2(N3) it has obtained the strong difference of total number of Ly–c photons between its determination by radio flux density and that by radio lines. Possibly this difference is needed to take into account in further study of these objects. Full paper was published in *Astronomicheskii Zhurnal* (1993, **70**, 72).

Key words: HII regions, O–B stars.

ON POLARIZATION PARAMETERS VARIABILITY OF OBSERVED GALACTIC RADIO EMISSION

O. M. Kovalchuk, V. A. Razin, A. I. Teplykh
Radiophysical Research Institute (NIRFI), Nizhnij Novgorod, Russia
e-mail: razin@astro.kis.nnov.su

ABSTRACT. Correslations between the solar activity and the observed polarization of the galactic radio emission are discussed.

Key words: Radio emission, polarization

Already during the first investigations of lineally polarized galactic radio emission in 1956–1962 it has been noted the correlation of polarized temperature T at a frequency of 207 MHz and the solar activity (Razin 1958, 1964).

It has been observed rapid irregular and very strong (up to 100%) daily variations of T and its slow variations with typical period of several months and years. The position angle of radio emission polarization plane Y has been also changed. A further multi years regular polarization observations of the galactic radio emission in the direction in the North Celestial Pole and to the area of strong polarization with galactic coordinates $l = 147°$, $b = +8°$ at a frequency of 290 MHz and in a frequency band of 195–215MHz carried out at Radio Astronomy Station Staraya Pustyn (NIRFI) have also discovered the variability of T and Y in a wide time intervals.

The analysis of measurement results for a period from 1977 to 1988 has showed that there is no direct dependence of T and Y on solar activity index $R9$ as well as the index of geomagnetic activity $C9$ while during the increase of solar activity from its minimum in 1983–1984 up to 1988 the mean value of T has been doubled. During this period Y was changing a little and only in summers 1984 and 1985 during 1–2 months it has been noted its variations from the average value on $30 - 40°$ taking place at the increase of the average value and strong fluctuations T (Teplykh and Kovalchuk, 1986).

Among possible reasons of variability of galactic radio emission polarization parameters one should consider the effects of radio wave propagation in nonhomogeneous magnetoactive plasma, the emission of nonstationar fluxes of high energy electrons in the Earth magnetosphere and interplanetary medium. At present time the correlation of T and Y variations with cosmic data is under investigation. The results of ground experiments are being used as well as those obtained at satellites and spacecraft.

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OPTICAL-RADIO TIME DELAYS IN Q0957+561

V. L. Oknyanskij
Sternberg State Astronomical Institute, Moscow State University
Universitetskij Prospect 13, Moscow 119899 Russia
E-mail: oknyan@sai.msk.su

ABSTRACT. Applying a specific cross-correlation method, we obtained evidence that changes in the radio flux appear to lag behind the optical variations of the quasar by about 6.4 years. Our analysis of rapid continuum variations gave some constraints on the sizes and on the differences between locations of radio and optical sources. In particular, it appears that the compact radio source may be so small that it can be affected by microlensing.

Key words: Galaxies - quasars; Cosmology - gravitational lensing

Introduction

Since the first gravitationally lensed quasar was detected (Walsh et al. 1979), the interest of astronomers in objects of this kind has been increasing every year. The reasons are not only an ordinary curiosity to a new exotic phenomenon, but also the hope to realize the determination of the Hubble constant via the time delay. Till now the first gravitational lens has remained the most attractive object for the time delay measurement (e.g. Beskin & Oknyanskij 1992, hereafter Paper I).

Several attempts have been made to determine the time delay τ_o in Q0957+561 (see references in Paper I). Using a special new method, in Paper I we obtained the value of the time delay $\tau_o \approx 1.45\ yr$ on the base of optical monitoring data. The purpose of present work was to use the radio monitoring data (Lehar et al. 1992) for determination the time delay beween A and B images variations and for investigations the optical-radio correlatons.

Time delays from the radio monitoring data

The radio data of the VLA monitoring Lehar et al. (1992) provides an additional opportunity to check the reality of the obtained value for the time delay. We reanalysed the data of Lehar et al. by the methods described in Paper I and obtained $\tau_o = 540 \pm 30$ days.

The radio and optical variabilities of some quasars are known to be correlated with time delays of about years (see, for example, Hufnagel & Breman 1992). We tried to see whether such a correlation may be present in Q0957+561, and (if possible) to estimate the value of the optical-to-radio time delay τ_{otr}. Essentially, we have four "eyes" through which we observe the same object: two at radio and two at optical wavelengths. Given the gravitational/geometrical time delay between the images A and B, we can combine these four data sets into two more complete sets, one optical and one radio. Then we can use the cross-correlation method of Peterson & Gaskell (1978) to search for a possible time shift between the radio and optical light curves. To decrease the noise from interpolations we add an improvement to their method: we take into account only such points of the interpolated data which are close enough to the real ones. The influence of the gaps in the combined light curves on the cross-correlation function is small because τ_o is about 1.5 years.

The radio and optical variations are strongly correlated (max of CCF is about 0.86) with a delay of $\tau_{otr} = 2340 \pm 30$ days.

To estimate the significance level of this correlation we applied the same Monte-Carlo method as in Paper I and found that the significance is better than 99%. That is there would be a very small chance to obtain the same high correlation if the light curves were really independent. Consequently we can conclude that the radio and optical fluxes have common origin of variability.

We predict that microlensing can occur at radio wavelengths, but the microlensing variations in radio and optical ranges are not necessarily correlated with each other. We shall discuss elsewhere possible physical models which can account for optical-radio correlations.

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EVOLUTION OF THE CRAB NEBULA RADIO EMISSION

E. N. Vinyajkin
Radiophysical Research Institute, Nizhnij Novgorod, Russia.
e-mail: evin@astro.kis.nnov.su

ABSTRACT. In 1977–1992 the flux density of the Crab Nebula in respect to Orion Nebula was measured at the frequency of 927 MHz with the same 10–m radio telescope. According to these measurements a mean rate of the Crab Nebula radio emission decline, (0.44 ± 0.16)% per year, was determined. This value is considerably more than the value (0.18 ± 0.01)% per year obtained for the previous fifteen years 1962–1977 (Vinyajkin E.N., Razin V.A.: 1979, *Austral. J. of Physics,* **32**, 93). It is possible that in addition to the steady secular decline of the Crab Nebula radio emission flux there are the flux fluctuations responsible for the variability of the mean radio emission flux decline rate determined with the use of ≈ 15–year periods observational data. The most probable cause of these fluctuations is a discreteness of the Crab Nebula radio structure.

Key words: Radio emission, Crab Nebula

ON THE TIME FREQUENCY DEPENDENCIES OF THE SECULAR DECREASE RATE OF CASSIOPEIA A RADIO EMISSION

E. N. Vinyajkin
Radiophysical Research Institute, Nizhnij Novgorod, Russia
e-mail: evin@astro.kis.nnov.su

ABSTRACT. Flux densities of young supernova remnant Cassiopeia A relative to those for radiogalaxy Cygnus A were measured in 1977-1992 at the frequencies of 290 and 927 MHz. These measurements were made with the same 10 m radiotelescopes at the Staraya Pustyn Radioastronomical Observatory (NIRFI). Decline of flux densities with time is not a steady one. There are deflections up to $\pm 3\%$ $(\pm 3 - 7\sigma)$ from the fitted power or linear time dependencies. The mean values of the rate of the flux densities decrease was determined to be $(0.88 \pm 0.11)\%$ per year at the frequency of 290 MHz and $(0.71 \pm 0.09)\%$ per year at the frequency of 927 MHz. The latter value is somewhat smaller than the value of $(0.95 \pm 0.04)\%$ per year for 927 MHz flux density decrease rate over 1962–1977 (Vinyajkin E.N., Razin V.A.: 1979, *Austral. J. of Phys.*, **32**, 93). The mean values of an annual decrease in 290 and 927 MHz Cassiopeia A flux densities over 1977–1992 do not contradict qualitatively with the frequency dependence of the secular decrease rate obtained by Vinyajkin E.N., Razin V.A., Khrulev V.V.: 1980, *Pisma Astron. Zh.*, **6**, 620.

Key words: Radio emission, Cas A.

ANALYSIS OF THE CCD CAMERA ST–4 AND OBSERVATIONS OF PX AND

I.L. Andronov[1], G.V. Borisov[2], L.L. Chinarova[1], S.S. Guziy[3], S.V. Kolesnikov[1], P.A. Mason[4]
[1] Department of Astronomy, Odessa State University, Odessa 270014 Ukraine
[2] SAI Crimean Laboratory, Nauchny 334413 Crimea, Ukraine
[3] Astronomical Observatory, Nikolaev Pedagogical Institute, Nikolaev 327000 Ukraine
[4] Department of Astronomy, Case Western Reserve University, Cleveland OH 44106 USA

ABSTRACT. Analysis of the spectral sensitivity of the CCD camera ST–4 is presented. The half-maximum sensitivity range is 685–930 nm. Mean wavelengths $\lambda_1 = \overline{\lambda} = 796$ nm, and $\lambda_2 = (\overline{\lambda^{-1}})^{-1} = 730$ nm are measured. Eclipses of PX And were detected at HJD 48861.3933 and .5393.

Key words: Stars: Cataclysmic: PX And

The spectral sensitivity of ST–4 is measured using a standard light source. Unfiltered test observations of PX And were obtained using the SAI 60–cm Zeiss telescope and SBIG ST–4 CCD Camera. Two comparison stars in the field are fainter than the variable, thus the resulting light curve (Fig.2) is noisier than would be expected from the counts themselves. The depth of the first minimum 1.1^m is larger than the values $\Delta V = 0.64^m$ and $\Delta R = 0.61^m$ obtained 55^d later (Shakhovskoy et al. 1995) when the star varied from $V = 14.04^m$ to 14.68^m. Thorstensen et al. (1991) noted a highly variable eclipse depth of about 0.5^m.

Our observations with the weakest count rates correspond to HJD=2448861.3914 and .5395. The phases are –0.012 and +0.001 respectively according to the ephemeris $T_{Min} = 2449238.8369 + 0.14635278 \cdot E$ (Hellier and Robinson 1994). The smoothed minima (see figure 2) correspond to phases +0.002 and –0.001 showing smaller deviations from the fit.

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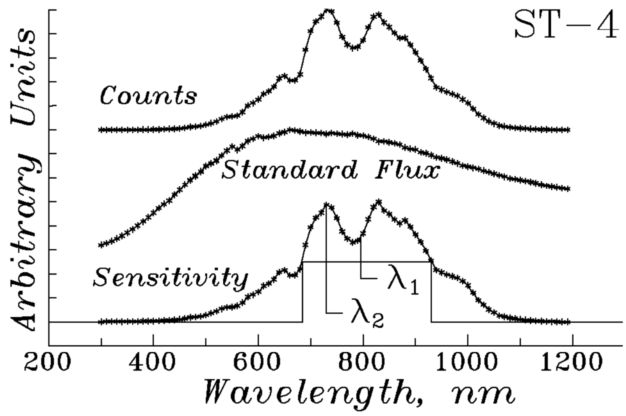

Figure 1. Spectral sensitivity of the CCD camera ST–4.

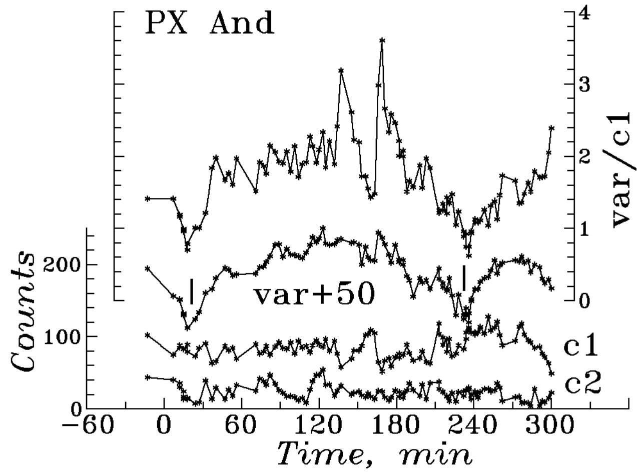

Figure 2. Counts of PX And and 2 faint comparison stars. Vertical bars show smoothed times of minima.

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NEW ASTRONOMICAL STATION ON MOUNT DUSHAK-EREKDAG. I. THE STATION.

N. I. Dorokhov[1], T. N. Dorokhova[1], N. S. Komarov[1], S. Mukhamednazarov[2]
[1] Astronomical Observatory, Odessa State University,
T.G.Shevchenko Park, Odessa 270014 Ukraine
E-mail: root@astro.odessa.ua
[2] Physical–Technical Institute, Turkmenian Academy of Sciences,
Gogolja, 15, Ashkhabad 744000 Turkmenistan

ABSTRACT. A new observational station of astronomical observatory of Odessa State University was put into operations in Kopet-Dag Mountains in Turkmenistan in summer 1992. The site has coordinates $\varphi = +37°56'$ N, $\lambda = 3^h52^m$ E; an altitude 2020 m. A meteorological characteristics and data on sky transparency are given. First observations of different objects show a good quality of data.

Key words: Astroclimate, observational station.

A new Central Asian station of astronomical observatory of Odessa State University was under construction on the south-western slope of the Dushak-Erekdag Mount in 1991. The site has coordinates $\phi = +37°56'$ N, $\delta = 3^h52^m$ E. An altitude of the site (2020 m) is higher than a level of a dust pollution of the air. A vast open horizon on the south permits to observe stars up to $\delta = -40°$.

A Ritchey-Chretien telescope with a primary mirror 80 cm in diameter was mounted at the station. The telescope has a relative aperture 1:14.3 and a field of view 20'. The telescope had produced by a group of Faschevsky N.N. and Paulin L.S., it has an original tubeless construction. A dual-channel photometer has been attached to the telescope. The photometer has been constructed at an astronomical spectroscopy department of the observatory of Odessa State University.

There are an observational station of Physico-Technical Institute and an a building observatory of research-astronomical enterprise "Asman", Academy of Sciences of Turkmenistan. The scientists of these institutes tested an astroclimate of the site in the seventies and the early eighties (Ovezgel'dyev et al. 1984).

Ashkhabad, the capital of Turkmenistan, is in 45 km to the east and illuminates the sky mainly. There are no other sources of the ambient light around.

In this site there are 160 clear days, 70 cloudy days and more than 2000 photometric hours per year. Due to weak winds (less than 3 m/sec) and the poor humidity of the air the atmospheric transparency is very stable in the season of summer-autumn.

These and other known astroclimatic features show that Dushak-Erekdag is comparable with Majdanak and Sanglok mountain. But recently this site has not been tested sufficiently enough and further investigations are needed.

First observations of different objects at the station: roAp and δ Scuti stars, a cataclysmic variable star TT Ari, the asteroid Toutatis etc., show a good quality of data. We took part in some international photometric campaigns by using the photometer during summer and autumn of 1992, 1993.

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NEW ASTRONOMICAL STATION ON MOUNT DUSHAK-EREKDAG. II. A DUAL-CHANNEL PHOTOMETER.

N. I. Dorokhov, T. N. Dorokhova
Astronomical Observatory, Odessa State University,
T.G.Shevchenko Park, Odessa 270014 Ukraine
E-mail: root@astro.odessa.ua

ABSTRACT. A dual-channel photometer has been constructed at Astronomical Observatory of Odessa State University to observe two astronomical objects simultaneously. The photometer has been attached to 0.8 m in diameter Ritchey-Chretien system telescope at a station of Odessa Observatory on the Mount Dushak-Erekdag in Turkmenistan. The equipment works in normal observing mode. Light curves of observations are presented.

Key words: Photometer: dual-channel; photometric observations.

A construction of the photometer of Astronomical Observatory of Odessa State University looks like a simple twin-beam photometer described in a work by De Biase et al. (1978), moreover some technical decisions we try to simplify. Our photometer permits to observe two astronomical objects at the same time.

Two symmetrical photomultipliers FEU-136 with thermoelectrically cooled photocathode S-20 are used in the photometer.

Each channel has a set of 5 diaphragms with diameters from 0.4 mm to 2.5 mm. A minimal distance between diaphragms of both channels is 4 mm in the focal plane, a maximal one is 100 mm (these correspond to 1′ and 20′ on a sky field for our telescope).

A wheel with 12 positions is located in each channel. The motor activated by the computer rotates the wheel. The moving time from one filter to another varies for disposition of the filters on the wheel from 1 to 3.5 sec.

We use the filters of the standard system of Johnson UBVRI and a narrow band interferometric filter with FWHM=140Å centered on the λ=4110Å (an analog of Stroemgren v-band) at present time. Besides, a radioluminescent sources for the stability equipment control and a set of neutral filters are mounted on the wheel. An observer can choose some set of filters.

It is possible for the photometer to observe the same star in both channels. A split prism moves in the way of the beam. We carry out simultaneous observations of the same star in different spectrum regions that permits to improve precision of the observations and to broaden the scope of astrophysical projects.

The photometer is adapted to decision of a wide range of astrophysical problems. An interface (it was produced in Kulibaba's V.V. laboratory) and a software of the system are described in a work by Dorokhov et al. (1990). The computer program provides integration times from 0.05 sec. to 32 sec. with a sampling 1 msec. A dead time between two measurements in the same filter is 0.018 sec.

The photometer has been attached to a 0.8 m telescope-reflector of the Ritchey-Chretien system (Dorokhov et al., 1994) at the Odessa Observatory station on the Mount Dushak-Erekdag in Turkmenistan.

In summer-autumn 1992 and in spring 1993 the observations of different astronomical objects were carried out on the photometer. Fig. 1 shows a light curve of the nova-like star TT Ari (Fig. 1a) and of the comparison star (Fig. 1b). Stroemgren band v was used

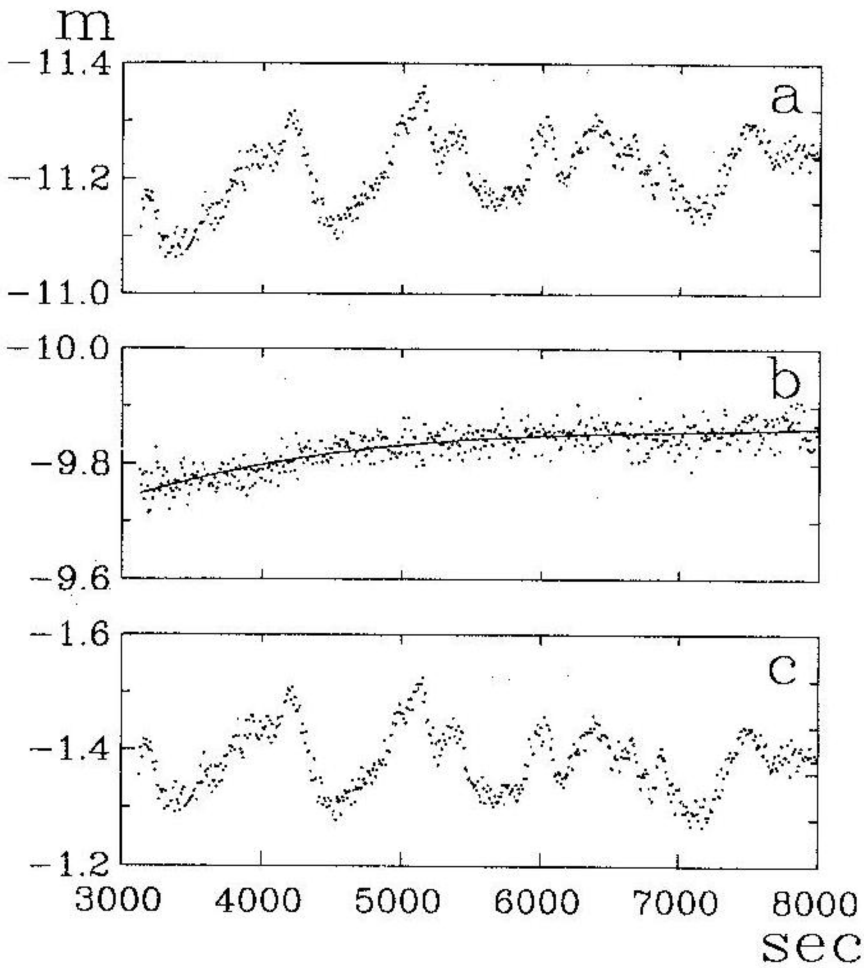

Figure 1: A light curve in instrumental magnitudes of the nova–like star TT Ari in a primary channel (a) with the comparison star in a secondary channel (b), a solid line is the smoothing data by polynomial of 3–rd order; c) – the result of subtraction of the smoothed secondary channel data from the primary channel data.

in both channels and integration time of 10 sec was chosen. A sky background was measured one time in an hour. Data are corrected for coincidence counting losses and a sky background contribution. A comparison star "c" (Götz 1985), an average of 1.4 mag fainter then TT Ari, is in 15′ distance from the variable. We smoothed the comparison star's data by polynomial of 3 degree for decreasing the statistical noise and subtracted this smoothed curve from light curve of variable star (in magnitude of instrumental system). This difference is shown in Figure 1c.

At present time we value a precise of observations by using the photometer in one–channel mode as 0.003–0.004 mag for the stars of 6 mag and as 0.01 mag for the stars of 10–12 mag for 10 sec. integration time when there is a good atmospheric transparency.

A dual–channel mode was not investigated enough but the instrumental drift in each of channels obtained by using radioluminescent sources is up to 3% during a night.

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NEW ASTRONOMICAL STATION ON MOUNT DUSHAK-EREKDAG. III. OBSERVATIONS OF THE roAp STAR HR 1217

N. I. Dorokhov, T. N. Dorokhova, D. E. Mkrtichian
Astronomical Observatory, Odessa State University,
T.G.Shevchenko Park, Odessa 270014 Ukraine
E-mail: root@astro.odessa.ua

ABSTRACT. Observations of well-studied roAp star HR1217 were obtained in Strömgren v-filter in single-channel mode for testing the possibilities of the dual-channel photometer. An accuracy of the single measurement is about 2.5 mmag after moving the principal periodic components from the data. Noise level in the whole frequency domain not exceed the 1 mmag.

Key words: Stars: Rapidly oscillating Ap stars; Individual: HR 1217

The rapidly oscillating Ap (roAp) star HR1217=DO Eri was investigated by Kurtz et al. (1989) during multisite campaign 1986. The star has clear periodicities with a principal frequency f=2.72 mHz and a modulated amplitude.

We had observed this star on 4.10.1992 during 97 minutes for testing the possibilities of the photometer (see referred paper). Observations were carried out in single-channel mode through the 45 arcsec diaphragm and narrow band interferometric filter with FWHM=140Å centered on the λ=4110Å (Strömgren "v"-band). The data comprised continuous 10-sec integration with the occasional interruptions for sky background measurements, were binned to 40-s time intervals, corrected for coincidence counting losses, sky background, extinction trend. Air masses varies from 1.8 to 1.5. The low frequency atmospheric extinction variations have been filtered with the Butterworth low frequency filter. The resulting light curve is presented in Fig. 1.

In Fig.2 we show the amplitude Fourier-spectrum of data which reveal the presence of unresolved multiplet structure around the frequency 2.72 mHz (Kurtz et al.,1989) produced the well visible light curve modulation in the Fig.1. A least squares fitting by using a program FOUR-1 by Andronov (1994) for this data set yields the frequency 2.726 $\pm$0.009 mHz and a semiamplitude 3.56 $\pm$0.35 mmag. The small peak with the amplitude 1.37 mmag at the frequency 3.91 mHz is a periodic error caused by a telescope worm wheel drive and some defocusing of the photometer Fabri lens.

Continuous line in Fig.1 show the synthetic curve, calculated with using the values of two principal frequencies (2.653 mHz and 2.72 mHz) from six frequencies resolved in frequency spectrum of HR1217 by Kurtz et al. (1989).

After moving the principal periodic components from the data we have got an accuracy of the single measurement about 2.5 mmag.

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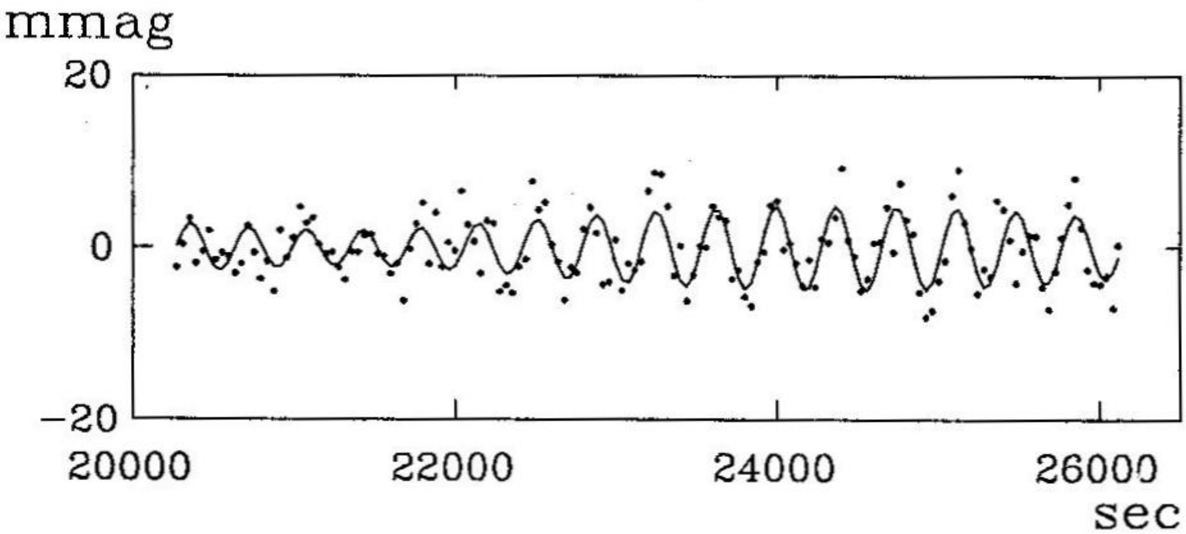

Figure 1: A light curve of the data. Continuous line shows the synthetic curve, calculated by using the values of two principal frequencies (2.653 mHz and 2.72 mHz) from Kurtz et al. (1989).

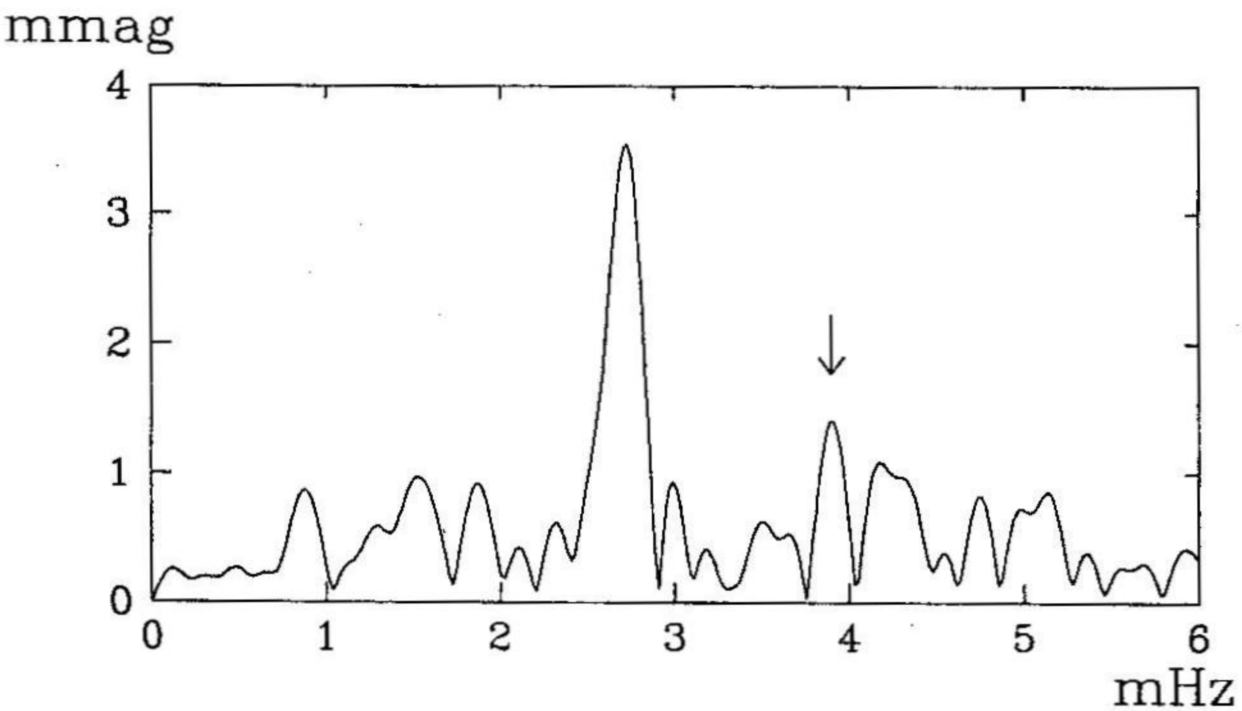

Figure 2: An amplitude Fourier-spectrum of data. A peak at a frequency 2.726 mHz with a semiamplitude 3.56 mmag is presented. An arrow shows a small peak at a frequency 3.91 mHz caused by a telescope worm wheel drive.

ENGINEERING DEVELOPMENT OF TELESCOPE CONTROL SYSTEMS

V. N. Ivanov, A. V. Ryabov, L. S. Paulin, A. F. Pereversentsev, M. G. Arkhipov
Astronomical Observatory, Odessa State University,
T.G.Shevchenko Park, Odessa 270014 Ukraine
E-mail: root@astro.odessa.ua

ABSTRACT. The engineering development of some variants of computer aided (automatic) control systems is presented for moderate telescopes with step–by–step drives as duty elements and with pulse sensors of BE–198 type as angular sensors.

Key words: Instrumentation: Telescope control system.

Two variants of a controller managing a step–by–step motor provide the use of a control computer in IBM PC standard. They permit to transfer information from sensors through a buffer into a unibus PC and provided software control of step–by–step drives of telescope.

Third variant is the independent module, which provides clock conducting of telescope, setting it in accordance with giving coordinates and output of real position of telescope to digital indicators.

Throughout a number of years, at the Odessa Astronomical observatory moderate telescopes with a mirror up to 1 meter in diameter have been engineered and manufactured. At present several such telescopes are working at the observatories of the Ukraine, countries of CIS and Eastern Europe. To a greater extent telescope operating performances are determined by its control system. The development and modernization of similar systems towards setting is enhanced, and functional possibilities are broadened.

Odessa telescopes are equipped with stepping executive mechanisms by turning a motor rotor by 1.5 degree per step that in using mechanical reductors with the reduction coefficient of 21600/1 provides rotation of a clock axis in steps by 0.25".

The motor control is carried out by an electronic drive with a quartz oscillator, a frequency divider with a variable division coefficient, a phase distributor and a power amplifier with the circuit of forcing phase currents.

The use of divider with a variable division coefficient permits to obtain some fixed rates of driving relative to a clock frequency F (for example, 0.1F, 2F, 10F) and to use them us rates of fast and slow corrections. The control circuit provides the deciphering of commands entering from the outboard control console or from the front panel of the device. The phase distributor with the account of reverse commands forms a three–phase sequence of pulses which after amplifying in power are fed into a stepping motor.

The multidigital divider (quantity of digits is determined by frequency of a master oscillator and a reduction factor) permits to set the rate of clock driving with high precision. For example, at oscillator frequency of 1050 kHz, a 24–digit divider and a reduction factor of 21600/1, the rate of clock driving is set in range from 0 to 600 steps/s with precision of 0.07 steps/s or 0.01"/s. With rise in oscillator frequency and increase in quantity of digits of a divider, one can decrease the value of its less significant digit and respectively increase precision of setting rate.

Because of mass application of computer technique and microprocessor set–ups, a real possibility has arisen of developing and introducing system if control of automated moderate telescopes.

At the Odessa Astronomical Observatory some variants if such automated system with step-by-step drives as executive elements and pulse sensors of BE-198 type as angular sensors have been developed. Sensors of this type provide formation of four-phase sequence of pulses on TTL levels with 90000 pulses in every phase per shaft revolution. In taking account of all the four phases it gives a value of one pulse from the sensor equal to 3.6". The sensors are installed on the telescope axes.

Using personal computers (PC) rather widely spread as control computers is of prospect for similar tracking systems.

At present two variants of a controller have been developed of stepping motors for the telescope by using as the basic PC type IBM AT-286.

Structurally, a controller represents a plate inserted into a connector of the unibus on a mother board of PC. With that, connectors are led into the PC back panel for switching on angle sensors, an outboard control console and power supply unit.

The first variant of the controller permits to transfer information from a sensor to a buffer and transmit it to a common bus of PC, to receive from the common bus and to transmit to a stepping drive the frequency of steps and the reverse signal. On the controller board,which that, a decipherer of address and commands, a buffer, a receiver and a transmitter to line are located. The control program should determine direction of rotation, calculate a turning angle and new telescope coordinates according to observational program, form a necessary step frequency and a signal of the reverse.

The second variant of the controller is constructed on the basis of a programmable timer K580BI53. One of the timer counters (C1) is used for forming pulse frequencies for a step-by-step motor, two others (C1 and C2) are for counting the number of pulses from the angle sensor in rotating towards one side and the other respectively. On the controller board, besides these, there are located a circuit of identifying rotation direction, a register of command signals and an oscillator. In other respects it is analogous to the first variant. The control program should periodically check the contents of registers of counters C1 and C2, determine a current angle, change, if necessary, the division coefficient of C0 and form signal of the reverse.

This variant of a controller is more complicated but it can be served by a compact resident program leaving a possibility of executing any other tasks for the computer.

A module of telescope control is developed and is being tested, it excludes using a control computer. Functionally, it works in the following way.

Signals from sensors are transformed into values of angular displacements in a digital code and are transmitted to indicators and to a comparison circuit. The set value of an hour angle is generated by an oscillator of hour angle and is also transmitted to indicators and to the comparison circuit. The comparison circuit gives a difference between the set hour angle and a current position of the telescope axis. This discordance taking account of its sing is controlling for an executive stepping drive.

As discreteness of a sensor of angular displacements is 14.4" in one phase, the telescope axis rotates in corresponding steps. One can decrease the discreteness by choosing frequency of a stepping drive, with that the smoothness of clock driving being improved.

The module of digital telescope control without using computers is structurally complicated incorporating over 80 packages of microcircuits of medium-scale integration but it can really be made under the conditions of astronomical observatories.

A PHOTOMETER

A. F. Pereversentsev, N. S. Komarov, M. G. Arkhipov,
E. A. Depenchuk, V. N. Ivanov, A. V. Ryabov
Astronomical Observatory, Odessa State University,
T.G.Shevchenko Park, Odessa 270014 Ukraine
E-mail: root@astro.odessa.ua

ABSTRACT. One-channel photometer is presented on the basis of a personal-professional computer designed for receiving information in 6 filters. It has control of a photoelectron tract by means of a radio-luminescence source. Information is brought out to the display and a file. The photoreceiver is cooled and thermostated. The maximum cooling amounts to 230K with ±0.5-precision of maintenance. The time of information accumulation ranges from 10 ms to 10 s with the discreteness of 10 ms.

Key words: Instrumentation: Photometer, Photoreceiver, Filter

Observations of stars constantly require still more precise data while investigation demand still fainter objects. These conditions imply the use of modified apparatus or the manufacturing of new ones, the application of modern photoreceivers, another procedure of carrying out observations and their processing.

At Odessa astronomical observatory, works are permanently carried out on the modernization of old apparatus and the producing of new ones (Pereversentsev et al. 1989, 1990), on the improvement of methods of observations and their processing.

In the given work, a one-channel photometer is presented which has been created at the Observatory. Its basis is a personal-professional computer intended for automation of a wide score of problems and IBM-compatible on parameters.

The photometer incorporates an optical-mechanical unit, a photoreceiver unit with thermostating, an amplifier-discriminator, a counter, a timer, and a matching circuit.

The optical-mechanical unit represents a cylinder inside of which a toothed disk is fixed with eighth holes in it. In rotating the disk the center of each hole crosses the optical axis of the photometer. The stepping motor gives a possibility of setting any hole with a filter fixed at the optical axis. An input radiation flux passes through the filter and gets to the jumping diaphragm and farther on to the Fabry lens and the photoreceiver. In one of the disk holes, a radio-luminescence radiation source is secured which is used for the control of an optical and electronic tract.

The transformed optical signal in the form of electronic signal pulses runs to the amplifier-discriminator [Pereversentsev A.F. at al. 1988] with a passband up to 100MHz and a gain of 1000.

The amplified and shaped signal in the standard emmiter-coupled logic (ECL) through a coaxial cable 15m long is applied to an eight digit counter. A less significant digit of the counter is executed at the fast-acting ECL, whereas the rest are executed at the transistor-transistor logic (TTL).

Information from the pulse counter is carried into the computer memory, displayed and recorded on a floppy disk 5.25" in diameter.

One of important problems is that of cooling photoreceivers aimed at decreasing thermo-electronic noises. We have developed and manufactured a number of thermo-electric cooling devices which have been used and are being used at different observatories [Kirpatch et al. 1988, 1989; Filin et al. 1990]. In our photometer, the system of thermo-cooling and thermostating [STOE] is applied which has been described in work [Shwets et al. 1990]. Temperature difference between hat and cold seals of the thermoelectrorefrigerator under load amounts to 70K whereas the depth of cooling depending on the type of a photoreceiver reaches 230K. The thermostating is kept with precision of ∓ 0.5K.

The control of processes of setting a necessary filter, time storage jobs, diaphragm input/output and information recording are performed with the computer program. The photometer work represents a series of subsequent operations, and this circumstance is used for the coincidence of timer functions and the control of a step–by–step motor. The coincidence circuit upon which the work of a timer and a step–by–step motor are based is used for both time storage jobs and for the job of step numbers. The time storage can vary from 10 ms to 10s with 1ms discreteness, more over, due to inner switches one can change the storage from 1ms to 1000 and more seconds.

The information processing can be carried out both at the site of the observation station and in the center.

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