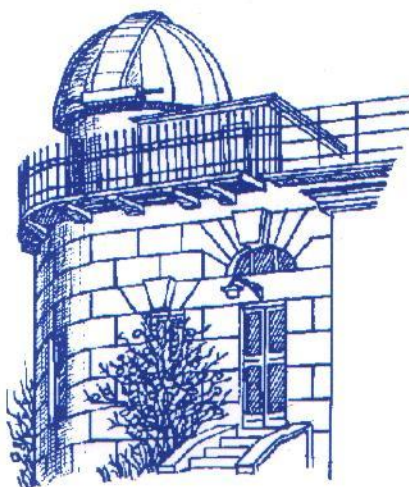


ODESSA ASTRONOMICAL PUBLICATIONS

Volume 10 (1997)



Odessa State University

**ODESSA ASTRONOMICAL
PUBLICATIONS**

Volume 10 (1997)

(Известия Одесской Астрономической Обсерватории)

Special issue dedicated to the 90-th anniversary
of the birth of Vladimir Platonovich TSESSEVICH.

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Печатается по решению Ученого Совета Астрономической Обсерватории
Одесского государственного университета им. И.И. Мечникова
от 15 сентября 1997 г., протокол N 7

Printed in the UKRAINE
ASTROPRINT PUBLISHING COMPANY

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FOREWORD

The present volume 10 of the "Odessa Astronomical Publications" (News of the Astronomical observatory) is the collection of papers based on the reports and posters presented at the International scientific conference "Variable stars", which was devoted to the 90-th Anniversary of the birthday of Vladimir Platonovich Tsessevich (1907-1983), the famous researcher of variable stars of the 20-th century.

The present conference has become traditional, carried out of time per four years both organized Astronomical Observatory and Department of Astronomy of the Odessa State University named after I.I.Mechnikov together with the Odessa Astronomical Society and at the support of the Euroasian Astronomical Society (Moscow) and the Ukrainian Astronomical Association (Kiev).

The conference took place on September 1-5, 1997 in the Odessa city, to which V.P.Tsessevich was connected during the last 39 years of his life, in the city, in which V.P.Tsessevich has organized and has carried out the research of large number of variable stars of different types, has created the school of researchers of variable stars, was the head of the Department of Astronomy and director of the Astronomical Observatory.

At the conference "Variable stars", the memorial session was carried out and worked 5 sections. During the conference, altogether 93 scientific reports and 37 posters were presented. Some of the reports presented at the conference, were published in other editions. Other 52 scientific papers and notes are offered to the reader in the present issue of the journal.

We thank the sponsorship of the Odessa department of the 'Vidrodzhennya' (renaissance) foundation and of the company "Odessagas".

V.P. TSESSEVICH - A WAY IN SCIENCE

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ABSTRACT. The biography of Vladimir Platonovich Tsessevich, one of the most prominent variable star researches, is briefly presented. The opening talk at the memorial conference "Variable Stars" (Odessa, September 1-5, 1997) devoted to the 90-th anniversary of the birth of V.P.Tsessevich.

Key words: History of Astronomy - Personalia: V.P.Tsessevich

Vladimir Platonovich Tsessevich is one among the most prominent researchers of variable stars of the 20-th century, who studied a huge amount of variable stars and collected one of the largest databases of observations of these objects.

He was born on October 11, 1907 in Kiev in the family of widely known opera singer Platon Ivanovich Tsessevich and his spouse Elisaveta Alexandrovna, the teacher of music. The father was a very picturesque figure and his many features were transferred to the son. However, soon the family has broken up. All remaining life the mother of V.P.Tsessevich lived together with the son, dividing with him unfortunes and successes.

Being 15 years old, V.P.Tsessevich became a student of the Petrograd University, since 1921 being engaged into observations of variable stars in a Society of "world knowledge" amateurs. At this time, the country was in a ruin and hunger, and it was necessary not only to learn, but also to earn on life. From this times began the teaching life of V.P.Tsessevich which lasted till his death in 1983. However, his scientific activity was even more active. He observed variable stars in all astronomical

observatories and societies of the Petrograd-Leningrad city. Having finished in 1927 the university education, V.P.Tsessevich already had 65 published scientific works. First ten of them have been printed in a respectable foreign magazine "Astronomische Nachrichten", when to the author was only 17 years old. The first love of V.P.Tsessevich were the eclipsing variable stars, on which he was the largest expert both in photometry and theoretical research.

It is no wonder, that after finishing the University, V.P.Tsessevich has become a PhD student under the supervision of G.A.Tikhov, who at that time was the recognized expert on photometry. At this time, in his publications there are researches of long-periodic and short-periodic cepheids, mira-type stars and other types of variable stars. Appeared the works on the theory of cepheids, on photometry of comets and asteroids, on the research of the mass ratio of eclipsing binary stars. He finished the PhD studentship in 1931, and began to teach in some of high schools of the Leningrad city. However, the scientific interests and acquired earlier reliance on more fruitful observations of variable stars in the southern regions of the country (resulted on his numerous annual summer trips for observation in Odessa), have resulted that in 1933 V.P.Tsessevich was sent to Tadjikistan and became the director of the Tadjik astronomical observatory in Stalinalabad and worked at this position in 1934-1937 years.

To the beginning of his directorship in Stalinalabad, V.P.Tsessevich had more than 130 published works devoted to research of different types of eclipsing and physically variable stars, study of the brightness variations of asteroids.

He already had, despite of rather young age, the authority of the recognized scientist and manager. It is no wonder, that Tadjik astronomical observatory at once became the one of the centres of research of variable stars.

At this time, the wide experience of observations of eclipsing variable stars is realized and there is a necessity to pay attention to perfection of the theory of determination of their orbital elements. V.P.Tsessevich begins calculations of the advanced tables of photometric phases. This work continued in Leningrad, where V.P.Tsessevich had moved, by leaving a position of the director of the Stalinabad astronomical observatory (nowadays the Institute of astrophysics of the Academy of Sciences of Tadjikistan). The results of calculations of the tables of photometric phases of eclipsing variable stars were included in his doctor's dissertation defended at the Kazan University in 1944, and in the third volume of the collective monography "Variable stars", issued in 1947.

The next stage of scientific creativity of V.P.Tsessevich is connected to the Odessa University. He was the head of the Astronomy Chair and the director of the Astronomical Observatory since autumn 1944 till October, 1983. At this time, V.P.Tsessevich was a doctor of sciences and Professor, one of the most outstanding scientists in astronomy, with a reputation of the largest researcher of variable stars. He had more than 200 scientific publications devoted to many astronomical problems. It is no wonder, that to the scientific problems being traditionally solved in Odessa observatory, the subjects on variable star research have joined immediately.

It is necessary to note, that in Odessa there were already the traditions of researches of variable stars: M.S. work by V.S.Zhardetsky on the study of a spectrum of the cepheid η Aquillae and a compilation of spectral observations of eclipsing binaries by A.M.Shulberg. However, these were the separate works divided by a large interval of time. V.P.Tsessevich has put the photometric researches of different types of variable stars in Odessa on the strong base and has made them the basic subject of the Odessa observatory. He has given to A.M.Shulberg

a new theme on theoretical researches of eclipsing variable stars and was the initiator of development by A.M.Shulberg of the first method of determination of elements of orbits of eclipsing variable stars with extended atmospheres by using the algorithm of Kozyrev and Chandrasekhar.

In Odessa V.P.Tsessevich realized the patrol service of the 'Anti-Algols' (i.e. shord-period cepheids or RR Lyrae -type stars) which was begun by him earlier. The systematic observation of these objects and tracking behaviour of their periods of the brightness variations was carried out. The Blazhko effect, and also other characteristics of stars of this type were carefully investigated. The different types of pulsating and eruptive stars were investigated, the new types of stellar variability were searched. The study of cataclysmic variables, research of the brightness variations of asteroids and many other explorations had begun. The edition of the "Bulletin" (at first), then of the "News of the Astronomical observatory" have begun.

V.P.Tsessevich has organized a substantial growth of the observatory staff (by a factor of 10), an expansion of subjects including the research of meteors and bolides; the photographic and radar-tracking observation; positional observations, both photometric and theoretical researches of the artificial satellites of the Earth; introduction of photoelectric and electrospectrophotometric methods of observations. V.P.Tsessevich has organized in Odessa the construction of telescopes, by creating for this purpose the optical, mechanical and electronic laboratories, which have made more than 30 telescopes and many other equipment.

Under the supervision of V.P.Tsessevich, the suburban astronomical stations in the villages Kryzhanovka and Mayaki were created, where is located a basic observational equipment of the observatory. At this time, the observatory enriched by a number of mountain observational stations in Armenia, on the Northern Caucasus (with a 80-cm a telescope), in Turkmenia. By the forces of V.P.Tsessevich, a large (about 200 thousands items) Scientific library, the Collection of patrol negatives of the stellar sky (about 100 thousands plates), have been

created, as well as the Depositarium of the unpublished photoelectric observations of variable stars (about 400 thousands observations).

Totally, V.P.Tsessevich has obtained about 500 thousands observation, has published more than 650 scientific papers and notes, a large number of the reviews, editorial papers, introductory papers and notes, reviews in the different encyclopedias and calendars. He was the co-author of large number of the collective monographies, the author of the monographies devoted to researches of the RR Lyrae and RW Aurigae – type stars, two monographies devoted to observation of variable stars in various constellations, the books "How to observe in the sky", which sustained 6 editions, "The Atlas

of finding charts of variable stars " (co-author M.S.Kazanasmass).

V.P.Tsessevich could not sit without scientific and educational work. Any time the visitor would come, he could see, that V.P.Tsessevich either measures the brightness of variable stars on photonegatives, or processes these observations, or prepares for lectures for the students, or works on papers and monographies. He did not suffer lazyness. For the schoolboys, students, post-graduate students, colleagues, among which more than ten doctors of sciences and more than 50 candidates of sciences, he always was an example of the relation to work, love to the science elected by him. V.P.Tsessevich died on October 28, 1983.

NEGATIVE SUPERHUMPS AND RED NOISE IN THE CATAclysmic BINARY TT ARIETIS: THE INTERNATIONAL CAMPAIGN "TT ARI-94"

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ABSTRACT. Results obtained during the international observational campaign "TT Ari-94" are briefly discussed. During 258 hours, totally 51299 observations were obtained in 12 observatories. The moments of 68 individual maxima and 74 minima are tabulated. The linear ephemeris for the maximum is $MaxHJD = 2449645.4255 \pm 0.0003 + (0.0133160 \pm 0.000004) \cdot E$ for our data obtained in JD 2449614–690. The period value is distinctly outside the interval $0.01326 - 0.013298$ obtained for previous years. It still corresponds to the 'negative superhump' state, whereas for

a normal 'positive superhump' the value predicted by Tremko et al. (1996, *As.Ap.* 312, 121) is $P = 0.01426 \pm 0.000006$. The data prewhitened in respect to the superhump variations show the red noise power-law power spectrum with an index $\gamma = 1.3...2.6$.

Key words: Stars – binary – novalike – superhumps, red noise; Individual: TT Ari

TT Ari is the binary system exhibiting a variety of phenomena causing its variability. Thus the observations have been carried out

occasionally since 1961. The main types of variability are the following:

- Spectral variations with phase of the orbital period $P_{orb} = 0.^d13755114$;
- Primary wave with a photometric period P_1 in the range $0.^d1326 - 0.^d13298$ prior to our observations;
- Possible beat between P_{orb} and P_1 ;
- Possible secondary photometric period of $P_2 \approx 0.^d1952$;
- Quasi-periodic oscillations with a cycle length of 14-20 minutes;
- Long-term variations of the mean brightness from 10 to 16 magnitude;
- Possible dips (brightness fadings at a minute time scale);
- Fast variability with a power-law power spectra.

Detailed overview and references one may find e.g. in Tremko et al. (1996). To study these phenomena, one should have observations from different observatories, if possible, overlapping and longitude - dispersed.

The international campaigns were organized in 1985 and 1988. Their results were summarized by Semeniuk et al. (1987) and Tremko et al. (1996). The present campaign "TT Ari - 94" is the first one with the observations obtained at very different longitudes - in Japan, Turkmenistan, Europe and USA.

The complete discussion of the results will be presented elsewhere (Andronov et al., *Astron. J.*, submitted). Here we only briefly describe the results and present the tables of the original timings of the extrema and the figure illustrating the night-to-night changes of the characteristics of the red noise, which will not be included in the final paper. The timings for the year 1988 are listed by Tremko et al. (1994).

As $P_1 < P_{orb}$, one may call such a phenomenon the "negative superhump", which is observed in few stars, but contradicts the theory of precessing elliptic accretion disk (cf. Patterson et al., 1997), if one suggests that the

primary photometric period P_1 coincides with the synodical period of the disk P_d . One may suggest that $P_1 = P_d/2$, and thus P_d will be a 'true' photometric period consisting of two nearly equal cycles. This is in an agreement with the initial suggestion by Smak and Stępień (1969), who first derived the value of $0.^d2658$.

The 'expected' value of the superhump period is usually larger than P_{orb} and may be determined from an empirical relation by Andronov (1990):

$$\lg P_{sh} = -0.0043 + 1.077 \cdot \lg P_{orb} \quad (1) \\ \pm 33 \quad \pm 6$$

In this equation the periods are expressed in hours. For TT Ari, $P_{sh} = 0.^d1493 \pm 0.^d0007$, as was predicted by Andronov et al. (1992) by using the value $P_{orb} = 0.^d13755114$ (Thorstensen et al., 1985).

The values of P_1 derived from the present observations are $0.^d133130$ (fit to the maxima) and $0.^d133118$ (fit to the minima). However, the sine fit to all data obtained at the Dushak-Eregdag station of the Odessa State University, corresponds to slightly other value $0.^d133160$ listed in the abstract. Such discrepancy exceeds the error estimates and may be interpreted by real relatively large phase shifts in different runs. In any case, the value of P_1 lies well outside the range of values previously determined.

Thus one may note, that during its study in 1961-1994, the normal positive superhump was never detected.

The quest of the secondary period suggested by Wenzel et al. (1986) on the data from 1985 year remains opened. Tremko et al. (1992) argued for a secondary 5-7 hour wave, but have failed to choose the best peak from the 4 candidates at the periodogram. This suggested period is longer than the usual observational run and thus the aliases at the periodogram are very strong. In the present data, in the range from 2.5 to 5.5 cycles/day there may be a wave with a frequency 3.2895 cycles/day and an amplitude of 25 mmag. There is no mechanism to make this wave coherent, thus possibly the amplitude of the wave is underestimated owed to the night-to-night phase shifts.

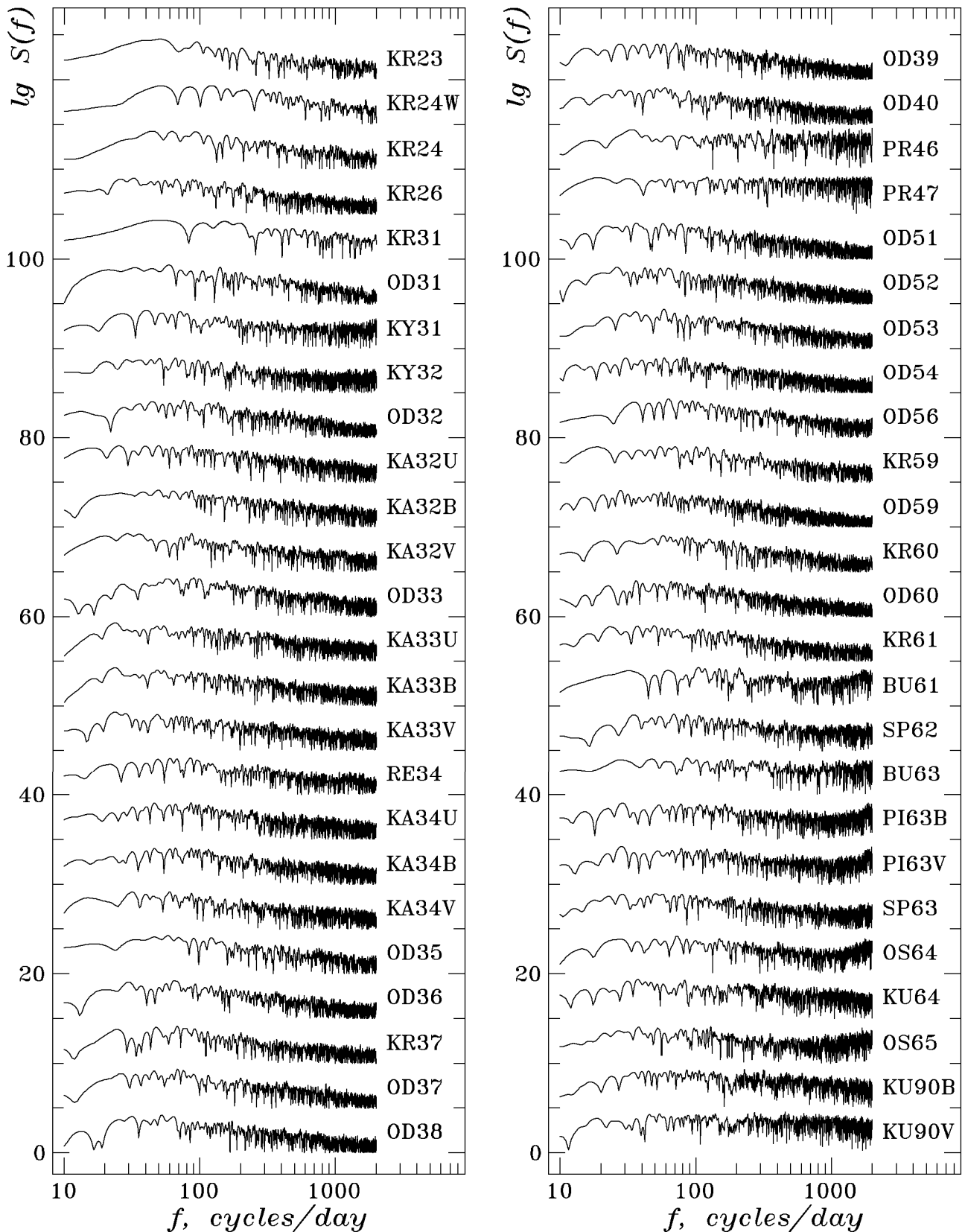


Figure 1. The periodograms for individual runs of TT Ari in a double logarithmic scale. The shift between the subsequent lines is set to 5. The runs are marked in the following way: two first letters correspond to the city or observatory then two last digits of JD. The data are usually in the B system, otherwise noted. The test function $S(f)$ is used (Andronov, 1994).

Table 1. Moments of the individual maxima from the running parabolae fits. The times are expressed as HJD-2449600.

Run	t	ϕ	m
CCD14	14.5207±0.0070	-0.087±0.053	0.129±0.011
CCD14C	14.5234±0.0062	-0.068±0.047	-0.048±0.009
KR24	24.5384±0.0022	0.143±0.017	1.073±0.002
KR26	26.4088±0.0015	0.189±0.011	1.115±0.002
KR26	26.5047±0.0017	-0.091±0.013	1.115±0.002
KY31	31.2106±0.0051	0.249±0.038	-1.963±0.006
OD31	31.4355±0.0020	-0.061±0.015	-1.203±0.004
KY32	32.1261±0.0060	0.124±0.045	-1.977±0.008
KY32	32.2333±0.0018	-0.071±0.014	-1.976±0.005
OD32	32.3860±0.0053	0.077±0.040	-1.159±0.002
KA33U	33.4393±0.0055	-0.014±0.041	-3.793±0.005
KA33B	33.4470±0.0021	0.044±0.016	-1.612±0.004
KA34V	34.3580±0.0015	-0.115±0.011	-0.239±0.004
KA34B	34.3875±0.0020	0.107±0.015	-1.602±0.003
KA34U	34.4080±0.0024	0.261±0.018	-3.789±0.005
KA34U	34.4881±0.0017	-0.137±0.013	-3.832±0.005
KA34V	34.4894±0.0009	-0.128±0.007	-0.351±0.005
RE34	34.4975±0.0087	-0.067±0.065	-1.227±0.004
KA34B	34.5001±0.0046	-0.047±0.035	-1.647±0.004
OD35	35.4188±0.0016	-0.148±0.012	-1.193±0.003
OD36	36.4081±0.0046	0.281±0.035	-1.114±0.004
OD36	36.5216±0.0028	0.134±0.021	-1.182±0.005
OD37	37.4442±0.0028	0.062±0.021	-1.258±0.003
KR37	37.4464±0.0023	0.079±0.018	1.210±0.002
OD38	38.3541±0.0041	-0.105±0.031	-1.164±0.004
OD38	38.4957±0.0064	-0.041±0.048	-1.207±0.005
OD39	39.4077±0.0022	-0.193±0.016	-1.116±0.004
OD39	39.4728±0.0024	0.297±0.018	-1.113±0.004
OD40	40.3485±0.0027	-0.127±0.021	-1.184±0.003
OD40	40.4135±0.0052	0.361±0.039	-1.189±0.006
OD40	40.4928±0.0033	-0.044±0.025	-1.264±0.005
PR46	46.6293±0.0061	0.040±0.046	0.115±0.009
PR46	46.7700±0.0048	0.097±0.036	0.094±0.008
PR47	47.9189±0.0060	-0.275±0.045	0.046±0.013
OD51	51.4309±0.0036	0.099±0.027	-1.207±0.005
OD51	51.5190±0.0033	-0.240±0.025	-1.133±0.003
OD52	52.3421±0.0031	-0.058±0.023	-1.225±0.006
OD52	52.4857±0.0023	0.021±0.018	-1.218±0.005
OD53	53.4274±0.0013	0.092±0.010	-1.156±0.004
OD54	54.2597±0.0014	0.343±0.011	-1.160±0.006
OD54	54.3411±0.0040	-0.046±0.030	-1.135±0.004
OD54	54.4801±0.0039	-0.002±0.029	-1.206±0.005
OD56	56.3434±0.0031	-0.009±0.023	-1.132±0.004
OD59	59.1593±0.0049	0.137±0.037	-1.064±0.005
OD59	59.2839±0.0040	0.073±0.030	-1.062±0.004
KR59	59.3858±0.0015	-0.162±0.011	1.225±0.002
OD59	59.5245±0.0018	-0.120±0.014	-1.131±0.004
OD60	60.2099±0.0038	0.027±0.028	-1.150±0.003
OD60	60.3316±0.0030	-0.059±0.022	-1.158±0.005
KR60	60.3354±0.0019	-0.030±0.015	1.127±0.002
KR60	60.4484±0.0015	-0.181±0.011	1.113±0.002
OD60	60.4753±0.0026	0.020±0.019	-1.188±0.005
KR61	61.4111±0.0021	0.048±0.016	1.161±0.002
SP62	62.3248±0.0065	-0.091±0.049	1.330±0.007
BU61	62.4442±0.0041	-0.193±0.031	1.336±0.009
SP63	63.3697±0.0086	-0.243±0.065	1.353±0.007
OS64	64.1966±0.0202	-0.034±0.152	0.329±0.006

Table 1 (continued)

Run	t	ϕ	m
BU63	64.3557±0.0128	0.161±0.096	1.344±0.009
BU63	64.4492±0.0041	-0.137±0.030	1.353±0.009
KU64	65.0130±0.0037	0.097±0.028	1.329±0.007
OS65	65.0115±0.0027	0.086±0.021	0.298±0.006
OS65	65.1186±0.0022	-0.109±0.017	0.337±0.007
KU64	65.1400±0.0027	0.051±0.020	1.297±0.008
OS65	65.2575±0.0070	-0.066±0.052	0.340±0.009
KU90B	90.9478±0.0049	-0.138±0.037	1.243±0.011
KU90V	90.9707±0.0061	0.034±0.046	1.578±0.021
KU90B	91.0770±0.0022	-0.168±0.017	1.320±0.007
KU90V	91.0826±0.0031	-0.126±0.023	1.631±0.010

Table 2. Moments of the individual minima from the running parabolae fits.

Run	t	ϕ	m
CCD14	14.6076±0.0072	-0.435±0.054	0.266±0.007
CCD14C	14.6143±0.0071	-0.385±0.053	0.068±0.007
KR23	23.5359±0.0025	-0.386±0.019	1.394±0.004
KR26	26.4588±0.0008	-0.435±0.006	1.024±0.002
KY31	31.2596±0.0050	-0.383±0.038	-1.872±0.009
KY32	32.0385±0.0059	0.466±0.044	-1.788±0.013
KY32	32.1875±0.0032	-0.405±0.024	-1.849±0.007
OD32	32.4447±0.0009	-0.482±0.007	-1.018±0.002
KA32B	32.4452±0.0012	-0.479±0.009	-1.470±0.003
KA32V	32.4491±0.0015	-0.450±0.011	-0.100±0.004
KA32U	32.4503±0.0008	-0.441±0.006	-3.585±0.005
KA33V	33.5038±0.0034	0.471±0.025	-0.095±0.006
KA33U	33.5145±0.0015	-0.449±0.011	-3.544±0.007
KA33B	33.5158±0.0010	-0.439±0.008	-1.474±0.005
RE34	34.4417±0.0012	-0.486±0.009	-1.354±0.004
KA34B	34.4446±0.0019	-0.464±0.015	-1.488±0.005
KA34U	34.4477±0.0024	-0.440±0.018	-3.694±0.007
KA34V	34.4493±0.0020	-0.429±0.015	-0.116±0.007
KA34U	34.5519±0.0019	0.342±0.014	-3.653±0.006
RE34	34.5565±0.0052	0.376±0.039	-1.299±0.004
OD35	35.3735±0.0014	-0.488±0.011	-1.092±0.004
OD36	36.4469±0.0030	-0.427±0.022	-1.081±0.005
OD37	37.3665±0.0019	0.479±0.014	-1.039±0.003
KR37	37.3707±0.0019	-0.489±0.014	1.053±0.003
KR37	37.5069±0.0019	-0.467±0.014	1.079±0.003
OD37	37.5138±0.0022	-0.415±0.017	-1.095±0.004
OD38	38.3050±0.0036	-0.473±0.027	-1.109±0.003
OD38	38.4392±0.0038	-0.465±0.029	-1.104±0.006
OD39	39.3713±0.0018	-0.466±0.013	-1.034±0.005
OD39	39.4403±0.0023	0.052±0.017	-1.084±0.004
OD40	40.3078±0.0042	-0.433±0.032	-1.142±0.005
OD40	40.3806±0.0022	0.114±0.016	-1.151±0.004
OD40	40.4404±0.0029	-0.437±0.022	-1.169±0.006
OD40	40.5306±0.0032	0.240±0.024	-1.206±0.006
PR46	46.6850±0.0064	0.459±0.048	0.249±0.012
PR47	47.8842±0.0076	0.464±0.057	0.101±0.012
PR47	47.9541±0.0107	-0.011±0.080	0.119±0.014
OD51	51.3335±0.0037	0.368±0.028	-1.083±0.005
OD51	51.4781±0.0028	0.453±0.021	-1.089±0.004
OD52	52.2966±0.0016	-0.400±0.012	-1.114±0.005
OD52	52.4229±0.0037	-0.451±0.028	-1.122±0.006
OD53	53.3486±0.0033	-0.499±0.025	-1.035±0.009
OD53	53.4876±0.0035	-0.456±0.027	-1.050±0.005

Table 2 (continued)

Run	t	ϕ	m
OD54	54.2950±0.0021	-0.392±0.016	-1.042±0.005
OD54	54.5307±0.0015	0.378±0.012	-1.053±0.006
OD56	56.2830±0.0039	-0.463±0.029	-1.034±0.005
OD59	59.2108±0.0021	-0.476±0.016	-0.937±0.006
OD59	59.3413±0.0021	-0.496±0.015	-0.983±0.004
KR59	59.4694±0.0009	0.467±0.007	1.115±0.002
OD59	59.4716±0.0016	0.483±0.012	-0.975±0.004
OD60	60.2660±0.0017	0.449±0.013	-1.031±0.003
OD60	60.3976±0.0025	0.437±0.019	-0.992±0.005
KR60	60.4025±0.0014	0.473±0.010	1.021±0.002
KR61	61.3297±0.0014	0.436±0.011	1.095±0.002
KR61	61.4700±0.0008	0.491±0.006	1.019±0.002
SP62	62.3869±0.0131	0.376±0.098	1.404±0.008
BU61	62.3930±0.0084	0.422±0.063	1.448±0.013
PI63B	63.3211±0.0035	0.392±0.027	1.527±0.007
PI63V	63.3244±0.0055	0.417±0.042	1.719±0.007
SP63	63.3256±0.0058	0.426±0.043	1.427±0.006
SP63	63.4435±0.0028	0.311±0.021	1.445±0.006
PI63B	63.4578±0.0143	0.418±0.107	1.464±0.008
PI63V	63.4786±0.0095	-0.425±0.072	1.673±0.009
OS64	64.1301±0.0031	0.467±0.023	0.190±0.009
OS64	64.2658±0.0062	0.486±0.047	0.242±0.008
BU63	64.4084±0.0049	-0.443±0.037	1.446±0.012
KU64	65.0639±0.0027	0.479±0.020	1.496±0.008
OS65	65.0587±0.0044	0.441±0.033	0.183±0.007
OS65	65.1909±0.0060	0.433±0.045	0.233±0.006
KU64	65.2009±0.0040	-0.492±0.030	1.462±0.006
KU90B	91.0200±0.0049	0.404±0.037	1.466±0.006
KU90V	91.0256±0.0105	0.446±0.079	1.773±0.021
KU90V	91.1626±0.0094	0.474±0.071	1.827±0.019
KU90B	91.1646±0.0158	0.490±0.118	1.549±0.008

The beat period of 3.^d8 was suggested by Semeniuk et al. (1987) but was not justified by the data from other years; from the 16 nights obtained in Dushak-Erekdag, one may assume a period of 2.^d916 which is by a factor of 1.43 smaller than that expected (4.^d171) for the current values of P_1 and P_{orb} .

The quasi-periodic oscillations are still present at frequencies from 46 to 95 cycles/day. Most often the QPOs occurred at 59 cycles/day, i.e. 24 minutes. The drastic run-to-run changes of the best fit frequency may be explained by the wavelet-like model by Tremko et al. (1996), when the 'shot noise' consists of pulses occurring randomly and resembling dumping sines rather than decaying exponents.

To study QPOs and more fast the flicker activity, we have removed the primary photometric wave by using the running parabola fit with $\Delta t = 0.^d05$. The power spectra of the detrended data show a linear branch in a double logarithmic scale, as one may see in Fig.1. The

duration of this branch is dependent on the quality of runs (the "signal/noise" ratio), the duration of run and the time resolution. The slope varies from 1.3 to 2.6.

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SCALEGRAM ANALYSIS OF THE VARIABILITY OF THE POLAR AM HER

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ABSTRACT. The characteristics of the brightness variations of AM Her are studied at time scales from seconds to decades by using the scalegram method proposed by Andronov (1997, *As. Ap. Suppl.*, **125**, 207). The unbiased scatter estimate increases with the filter half-width according to a power law with an index 0.180 from 10^{-4} to 3000 days indicating a fractal nature of irregular variations with a low dimension of $D = 0.32$.

Key words: Stars: Cataclysmic: Polars: AM Her

AM Her exhibits a variability detected in a wide range (see e.g. Andronov, 1987ab for a review):

- seconds - accretion column oscillations; asymmetric boiling;
- tens of seconds - the "shot noise" caused by bombardment of the column by plasma inhomogeneities ("spaghetti");
- dozens of minutes - variations caused by clustering of small flares;
- 3 - hour wave and its harmonic - variations at the orbital period which is nearly equal to the spin period of the white dwarf with an arbitrary deviation $\leq 10^{-4}$;
- cycle-to-cycle and night-to-night variations of the light curve shape caused by physical variability of accretion structures;
- fast transitions between the high and low states with a minimum duration of ≈ 3 days;
- few year variability of the mean luminosity caused by either magnetic activity of the secondary, changing orientation of the magnetic axis of the white dwarf in respect to the secondary, minor variations of the orbital separation owed to a low-mass third body at an eccentric orbit.

This paper is based on our observations carried out at the 2.6m telescope of the Crimean Astrophysical Observatory with a typical time resolution of 4–5 seconds. During one of the nights (20.10.1993), the resolution

was set to 1 sec, and we have used it for the study of flickering.

To study the long-term variability, we have used the observations from the AFOEV database. To avoid an additional noise caused by shifts of the instrumental systems of different observers, we have used the data obtained by only one observer - M. Verdenet (1997) from 1976 to 1997. After removing the "bad" and "fainter than" points, altogether 1313 points remained.

In Fig. 1 the photoelectric light curve with 1-sec resolution as well as the visual long-term light curve are shown with corresponding scalegrams. As the test functions, we have used σ_{O-C} ($= \sigma_1$ in the notation of Andronov (1997)), i.e. the unbiased estimate of the scatter of the data near the smoothing curve; the coefficient $R = N_{eff}^{-1/2} = \sigma[x_C]/\sigma_{O-C}$, the weighted r.m.s. accuracy estimate at the arguments of observations $\sigma[x_C]$ and the amplitude "signal/noise" ratio $S/N = \sigma_C/\sigma[x_C]$.

One may see the jumps between the two parts of the curves owed to different accuracy and exposure time. A prominent peak occurs at $\Delta t = 0^d025$ corresponding to a non-sinusoidal character of the orbital light curve. For the long-term data, the peak occurs at $\Delta t = 750^d$ with a very weak peak at $\Delta t = 60^d$.

However, the dependence of σ_{O-C} on Δt is remarkable straight in a double logarithmic scale within a very wide range from 10^{-4} to 3000 days. The best fit is the following:

$$\lg \sigma_{O-C} = -0.796 + 0.1799 \cdot \lg \Delta t. \quad (1)$$

$$\pm 3 \quad \pm 13$$

For smaller values of Δt , the uncorrelated photon noise becomes compatible with a contribution of flickering, thus the slope decreases. For larger values, the slope tends to zero because of finite length of the run.

To study night-to-night changes, we have computed the scalegram for all runs. The noise characteristic σ_{O-C} for 24 runs is shown in Fig. 2. One may note a remarkable gathering of the corresponding curves with a total width of $\approx 40\%$ with few outstanding curves corresponding to low level of flickering (bottom curves) or extra variations owed to bad weather conditions.

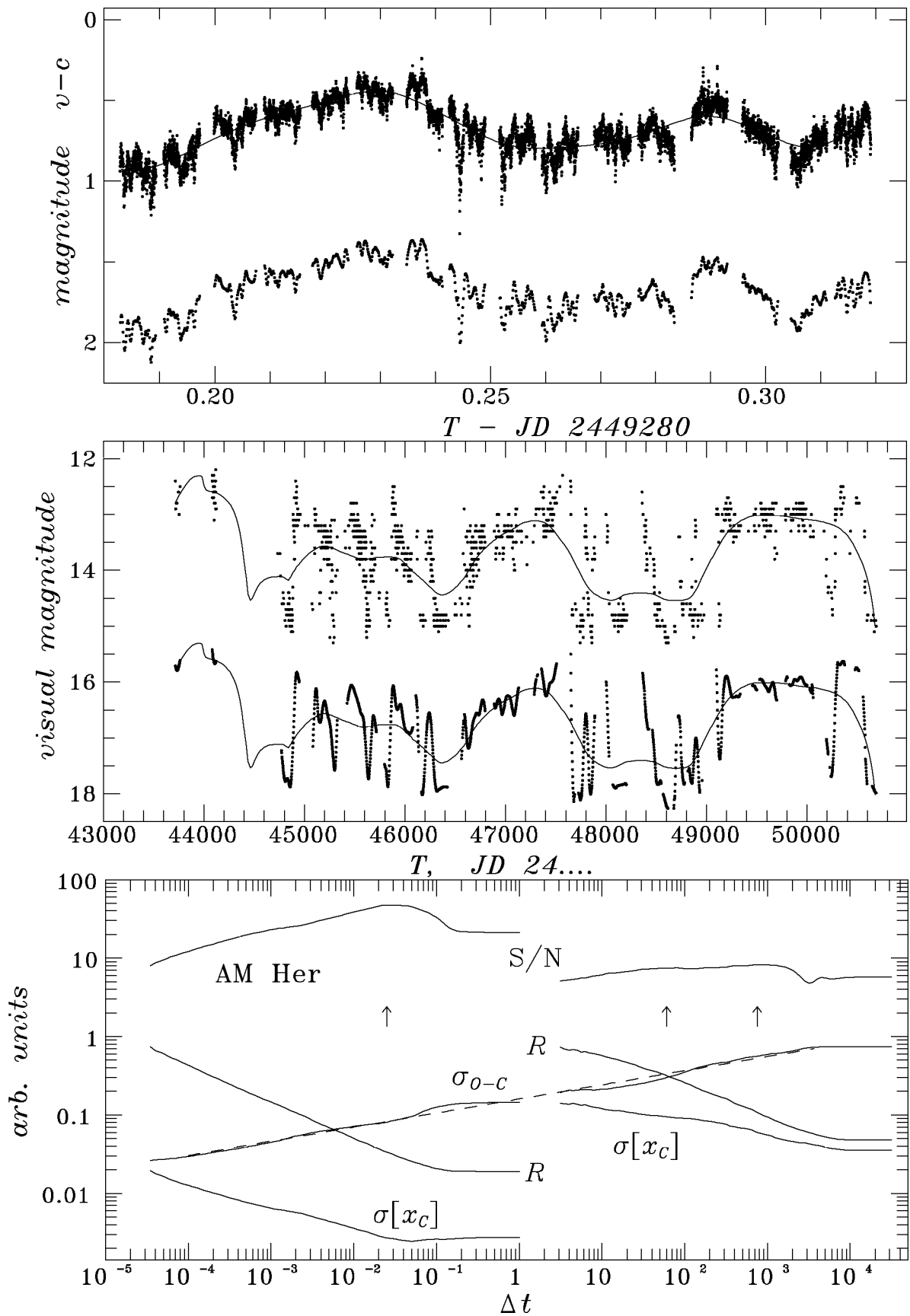


Figure 1. Brightness variations of AM Her at different time scales and the running parabola fits $\Delta t = 0^d025$, 60^d and 750^d (up - photoelectric and middle - visual) and the scalegrams for both sets of data (bottom). The arrows mark the positions of the (local) maxima at the S/N test function.

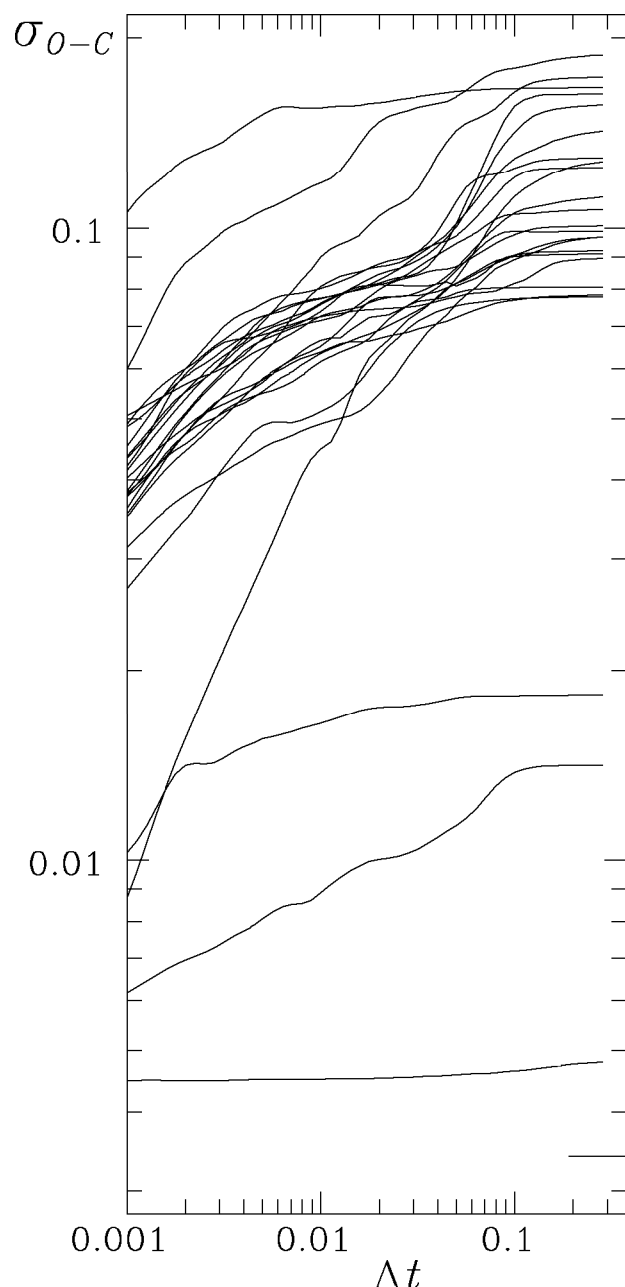


Figure 2. Test functions σ_{O-C} for 24 nights of 1-sec observations of AM Her obtained at 2.6m telescope.

The highest slope has the scalegram corresponding to the night 29.08.1992, when an unprecedented flare of the red dwarf was observed (Shakhovskoy et al., 1994). For the mean of all curves, the coefficients of the fit (1) are 0.67 ± 0.05 and 0.172 ± 0.014 . Thus the mean slope is equal to that of our 1-sec run within error estimates.

More careful study may allow to split the range into 3 parts. The first for the range $-3.0 \dots -2.5$ of $\lg \Delta t$ has a larger slope than from -2.5 to -1.5 . For larger Δt , there is an increase caused by growing systematic differences between the fit and harmonic of the orbital light curve, and then followed by a standstill owed to finite length of the run.

From this point of view, one may recommend to use the value of $\Delta t \approx 0^d035$ as the one best fitting the two-wave orbital variations.

Such linear shape of the dependence in the double logarithmic scale allows to propose some measures of the flickering, e.g. $I(\lg \Delta t) = \lg \sigma_{O-C}(\lg \Delta t)$ at some fixed values of $\lg \Delta t$, say, $-3, -2.5$ and -1.5 . These values have been introduced for AM Her concretely, and may be changed for other objects. The slope may then be determined as $\gamma_\sigma = (I_2 - I_1) / \lg(\Delta t_2 / \Delta t_1)$ and thus will be similar to the color index derived from a continuous spectrum. Detailed study of these parameters I will be done elsewhere.

As the value of σ_{O-C}^2 characterizes the energy integrated from some effective limiting frequency $f = \alpha / \Delta t$, where α is a parameter depending on the basic functions used for the fit, one may assume that the power spectrum will obey a power law as well. An index $\gamma_S = 1 + 2\gamma_\sigma$. For our case, $\gamma_S \approx 1.36$, in an excellent agreement with our findings in previous years (cf. Shakhovskoy et al., 1992). Much larger slopes $\gamma_S \approx 1.8$ have been found for nonmagnetic cataclysmic variables, e.g. TT Ari (cf. Tremko et al., 1996).

One may note the same slopes γ_σ for fast and slow variability of AM Her producing the power law in a range of frequencies differing by 7.5 orders.

As the variations are fractal, there is no possibility to obtain some characteristic cycles from the σ_{O-C} test function. The S/N ratio is more sensible to detect possible quasi-periodic or cyclic variations. In Fig. 1 we show the fits corresponding to the maxima of the dependence of S/N on Δt , including the local one at $\Delta t = 60^d$. From the continuous approximation, the optimal value of $\Delta t \approx 0.545P$, where P is the period of a regular contribution.

The parameter $\gamma_S = 2(1 - D)$, where D is so-called fractal dimension (cf. Terebizh, 1992). Thus one may conclude that $D = 0.5 - \gamma_\sigma$ and, for AM Her, the fractal dimension $D = 0.32$.

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PHOTOGRAPHIC STUDY OF ECLIPSING BINARIES

IY Aur, RX Ari, DG Per, ZZ Cnc

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ABSTRACT. Photometric elements for four stars, brightness of the comparison stars and moments of 67 weakenings are determined.

Key words: Stars - binary - eclipsing: Individual: IY Aur, RX Ari, DG Per, ZZ Cnc

The investigated stars were measured on the photographic plates of the Sky Patrol of the Astronomical Observatory of the Odessa State University. The brightness of the comparison stars was determined by linking to the standards in the Pleiades (for RX Ari), Champ 13 (IY Aur), h Per (DG Per) and NGC 2323 (ZZ Cnc). The brightness of the standard stars was published by Kazanasmas et al. (1979). The finding charts are shown in Fig.2. The brightness of the comparison stars is listed in Table 1. For the periodogram analysis, we have used the method described by Lafler and Kinman (1965) and realized among other algorithms in the set of computer programs by Andronov (1994). The phase curves are shown in Fig. 1.

RX Ari. The total duration of the eclipse is $D = 14$ (per cent of the orbital period), the duration of the total eclipse $d = 3$. The mean range is $8^{\text{m}}80 - 9^{\text{m}}05$. The depth of secondary minimum is nearly 1/3 of the depth of the primary eclipse, i.e. $\text{Min.II} = 8^{\text{m}}85$.

IY Aur. Brightness at maximum is $9^{\text{m}}48$, $\text{Min.I} = 9^{\text{m}}69$, $\text{Min.II} = 9^{\text{m}}55$.

ZZ Cnc. No period variations are detected. The secondary minimum is doubt, the range is $8^{\text{m}}2 - 8^{\text{m}}4$. Our period is two times larger than that published in the GCVS.

DG Per. The range $13^{\text{m}}2 - 13^{\text{m}}7$, the depth of the secondary minimum is $\leq 0^{\text{m}}06$.

Acknowledgement. The author is thankful to I.L.Andronov for helpful discussions.

The photometric elements

Star	n	P	T_0
RX Ari	114 pv	1.02962 ± 0.00027	45735.076 ± 0.003
IY Aur	168 pv	2.79341 ± 0.00099	44943.293 ± 0.001
ZZ Cnc	174 pv	25.4908 ± 0.0043	45566.671 ± 0.003
DG Per	206 pg	56.7527 ± 0.0019	$46254,184 \pm 0.002$

Moments of weakenings (HJD 24.....)
and corresponding brightness

RX Ari		IY Aur		DG Per	
42418.2729	9.05	43518.4214	9.61	41596.4815	13.62
42982.5024	8.92	44253.3587	9.61	41598.4424	13.65
43401.5257	8.83	44996.2742	9.68	44490.5234	13.63
43403.5484	8.81	44996.3020	9.67	45231.5122	13.20
45588.5588	8.80	44996.3319	9.69	46079.2076	13.25
45589.5593	8.86	45264.6004	9.55	46081.2194	13.68
45592.5630	8.87	45641.5124	9.68	46306.5586	13.61
45593.5495	8.83	45641.5385	9.68	46762.3686	13.68
45621.4762	8.86	46359.5490	9.68	47044.5580	13.70
45622.4680	9.04	46359.5757	9.53	48178.4548	13.20
46003.4157	9.04	46387.4816	9.65	48179.4495	13.66
47176.2137	8.81	46387.5055	9.52	48181.4323	13.68
47879.3038	8.79	46795.4197	9.47	48182.4437	13.18
48162.5368	9.05	47155.4005	9.56	48918.4356	13.68
48163.5539	9.05	47828.5986	9.57	ZZ Cnc	
48541.4747	8.88	47834.5348	9.61	40622.4055	8.13
IY Aur		42423.3562	9.56	41768.3189	8.21
40968.3095	9.55	42454.3020	9.69	41769.2974	8.19
40976.2988	9.50	43166.3257	9.55	42507.3036	8.13
41652.4772	9.68	47834.5612	9.46	45642.6123	8.09
41708.3666	9.66	47915.3669	9.68	47860.5413	8.19
41708.3957	9.68	48180.5702	9.53	47860.5659	8.29
41719.5649	9.68	48183.5609	9.68	47860.5904	8.30

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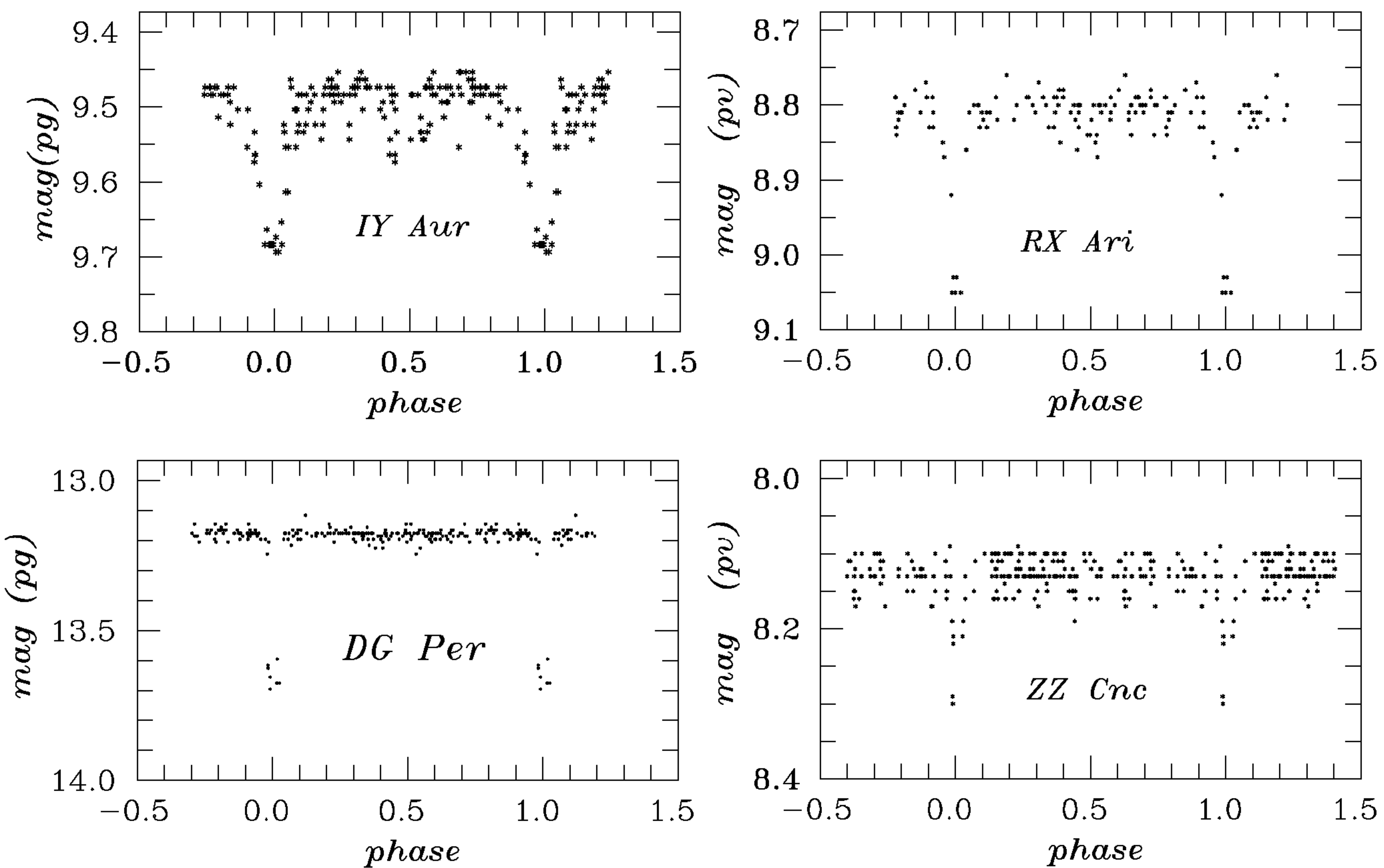


Figure 1. Phase light curves for the stars studied.

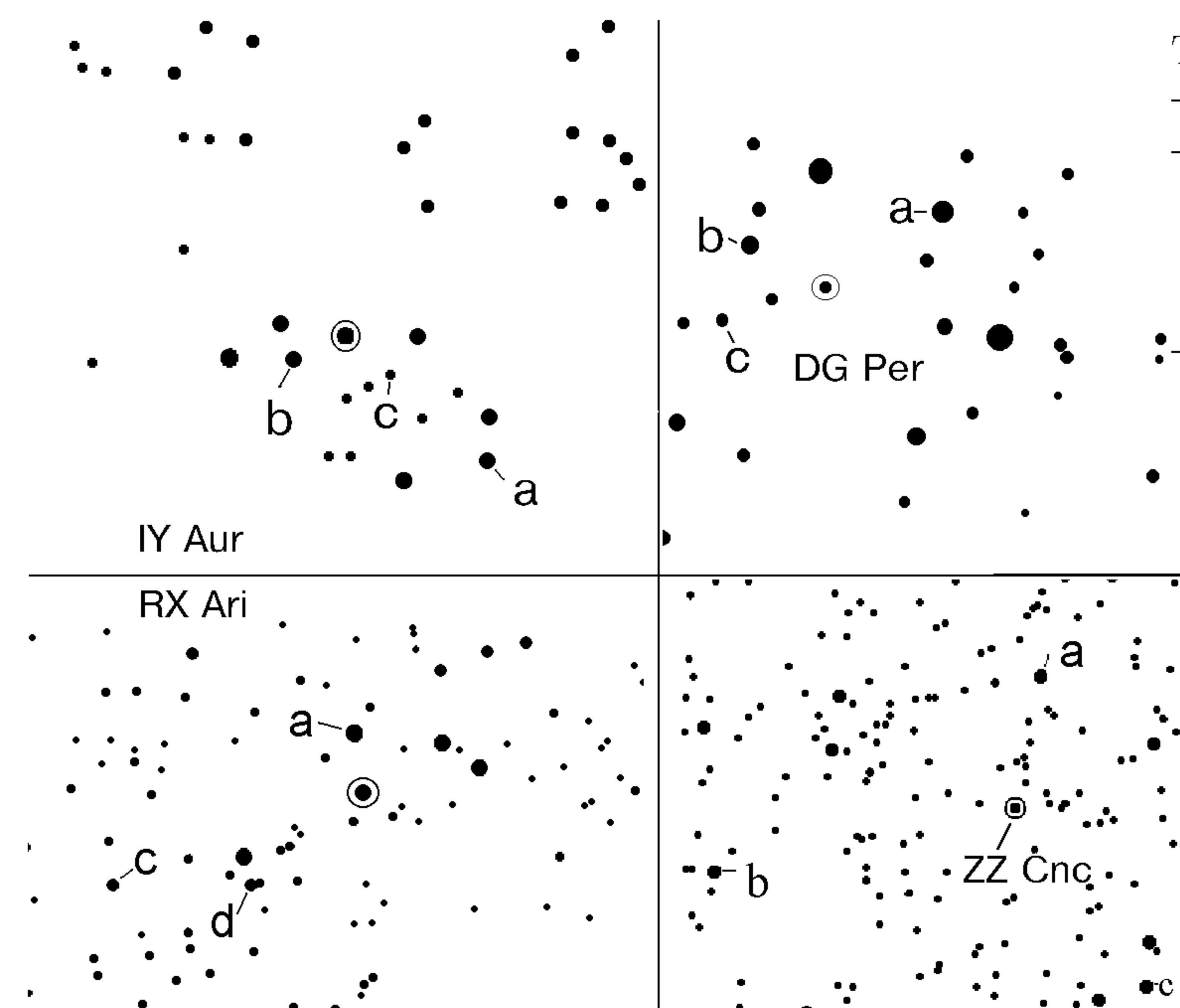


Table 1. Magnitudes of the comparison stars

Star		a	b	c	d
IY Aur	pv	9.38	9.66	9.72	-
RX Ari	pv	8.09	8.73	8.95	9.22
DG Per	pg	13.02	13.39	13.76	-
ZZ Cnc	pv	7.74	8.04	8.28	-

Figure 2. Finding charts for the investigated stars.

THE EVOLUTIONARY CONNECTION AMONG CLASSES OF CLOSE BINARIES

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ABSTRACT. The evolutionary connection of different types of close binaries is suggested. The early type contact systems are presented as one of the evolutionary stages of close binaries.

Key words: Contact early binaries (CE-stars), low-massive detached systems (DS), semidetached systems (SDS), KW-type systems (KW), similar KW ($\sim$ KW), period change.

The modern investigations of low-mass close binaries ($M_{1,2} = 1.5M_{\odot}$) point to evolutionary connection of their different classes. On the base of study of the close binaries is classification made by Svechnikov (1980).

Many works, studying individual close binaries, observed papers, devoted to total classes of close binaries, statistical researchs of Catalogues of binary stars, the study of position of components on the different diagrams give possibility in more detail to learn individual classes and to follow their mutualconnection.

More complete the idea of the connection of classes of close binaries (especially of low-mass systems) follows from the primary mass - large semiaxis diagram, which was considered by Svechnikov (1984) for the first time.

Also the significant interest presents the diagram of degrees of filling of Roche-lobes by the components of eclipsing binaries of different types (Karetnikov, 1989), which was made on the base of Svechnikov's (1986) Catalogue.

Svechnikov and Snezhko (1974) divided out the region without unevoled close binaries on the primary mass - large semiaxis diagram ($M_1 = 1 - 5M_{\odot}$, $A = 7.9 - 10R_{\odot}$). This region contained only semi-detached systems.

Next investigations showed that contact binaries of the early spectral types are in prohibited region. Physical parameters of components of CE-stars point on evolutionary unhomogeneous of these systems. About half of CE-stars from prohibited region experienced role exchange, other half became contact systems on main sequence yet. One may suppose, that exist next evolutionary chains, where CE-systems were missed with link;

$$\begin{aligned} & \text{DS} \rightarrow \text{SDS} \rightarrow \text{CE} \rightarrow \text{KW}, \\ & \text{DS} \rightarrow \text{CE} \rightarrow \text{KW}, \text{DS} \rightarrow \sim\text{KW} \rightarrow \text{KW}. \end{aligned}$$

The transition from CE to KW demands proves, because except angular momentum loss must be loss of mass. For CE-systems without role exchange mass ratio of the components is $q \leq 0.5$, the degree of filling of Roche-lobes of the components is 90-100% and more, degree of filling of Roche-lobe of the primary is equal or more of the same mean for secondary component.

Systems with role exchange have secondaries fill their Roche-lobes more than degree of filling of Roche-lobe of primary, mass ratio is $q \approx 0.15 - 0.45$. Svechnikov et al. (1989) note that majority of low-mass detached systems during evolution not become ordinary semidetached systems. For detached systems with orbital period ($P \leq 1.3$ day), the angular momentum loss occurs due to magnetic stellar wind (MSW).

Due to fast loss of angular momentum with too small mass loss, the large semiaxis decreases and contact configurations is formed. Author pointed on transition of detached systems to KW, if $A \approx 10R_{\odot}$. If $A \leq 10R_{\odot}$ (the top of prohibited region), it is possible the transition $\text{DS} \rightarrow \sim\text{KW} \rightarrow \text{KW}$ during $2 \times 10^8 - 4 \times 10^9$ years.

Many semi-detached systems are formed from DS due to role exchange with an angular momentum loss. A small group of low-mass DS with short periods (R CMa - type) evolves with angular momentum loss and strives to the contact if $A \approx 3R_{\odot}$. This group of binaries in the course of role exchange happens mass loss in surrounding area. For example, EE Aqr, YY Cet are low-mass CE-stars, which appeared from semi-detached R CMa-type systems. According the Catalogue by Bondarenko and Perevozkina (1997):

	μ_1	μ_2	q
EE Aqr	97%	100%	0.32;
YY Cet	93%	103%	0.49.

Such CE-systems as X Car ($\mu_1 = 99\%$, $\mu_2 = 94\%$, $q = 1$) and GK Cep ($\mu_1 = 99\%$, $\mu_2 = 98\%$, $q = 0.92$), according to Svechnikov and Snezhko (1974), became contact stars on the main sequence without role exchange.

In the work by Pustynnik (1989) also it is pointed on evolutionary transition among classes of close binaries: DS $\rightarrow$ SDS $\rightarrow$ KW. For example, the author says, that YY Cet passes to KW-type. The systems BF Aur, V1425 Cyg, RT Scl are on the stage before role exchange, after that KW-system of A-type will be formed. But all these systems are concerned to be CE-stars (Bondarenko and Perevozkina, 1997) at present and have parameters:

	μ_1	μ_2	q
BF Aur	97%,	99%,	0.99;
V1425 Cyg	95%,	102%,	0.39;
RT Scl	93%,	125%,	0.43.

Thus, according to criterions of divisions of CE-system into evolved and unevolved (after and before role exchange), BF Aur - before role exchange, V1425 Cyg and RT Scl - after.

Learned by Karetnikov (1989) diagram of degrees of filling of Roche-lobes has an evolutionary character, too. Suggesting that $\sim$ KW and KW consist of the stars of main sequence with 100% filling of their Roche-lobes, one can suggest such evolutionary chain ($M_1 \leq 1.5M_{\odot}$):

$$\text{DS} \rightarrow \sim\text{KW} \rightarrow \text{KW}.$$

The author showed that the filling of Roche-lobe was not connected with hydrogen burning in core and its squeezing, but decreasing of period and large semiaxis take place due MSW. These pointed transitions are possible for systems with $P < 3$ days.

The transition DS $\rightarrow$ $\sim$ KW passes during $8.7 \times 10^7 - 2.1 \times 10^9$ years, it is demanded 3.5×10^7 years for transition $\sim$ KW to KW. However, if to examine the Karetnikov's diagram, appears the idea about the following transition:

$$\text{SDS} \rightarrow \text{CE}, \text{SDS} \rightarrow \text{KW}.$$

But the author did not examine that transition. The regions of CE and KW are crossed on the diagram.

Conclusion

1. For loss-mass close binaries (if one component has mass $M \leq 1.5M_{\odot}$, $A \leq 10R_{\odot}$, $P < 3$ days), there are possible the next evolutionary transitions:

- DS $\rightarrow$ SDS (R CMa-type) $\rightarrow$ CE,
DS $\rightarrow$ $\sim$ KW $\rightarrow$ KW
(Svechnikov et al., 1989);
- DS $\rightarrow$ $\sim$ KW $\rightarrow$ KW (Karetnikov, 1989).

2. Including CE-stars in examination of the evolution of low-mass binaries systems possible next transitions (on the base primary mass - large semiaxis diagram):

$$\begin{aligned} \text{DS} \rightarrow \text{SDS} \rightarrow \text{CE} (\rightarrow \text{KW} ?), \\ \text{DS} \rightarrow \text{CE} (\rightarrow \text{KW} ?). \end{aligned}$$

(Bondarenko and Perevozkina, 1997).

Problems:

1. It is possible the formations of low-mass CE to KW? If it is possible, how to explain great loss of matter?
2. Is it possible the formation of CE-systems from ordinary (not R CMa-type) SDS systems?
3. How to answer the question of Karetnikov (1989): what mechanism prevents from merging of the components of KW systems in one star? Are there any data about formation of one star from close binary?

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THE PERIOD CHANGES AND EVOLUTION OF CONTACT BINARY STARS OF THE EARLY SPECTRAL TYPE

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ABSTRACT. The analysis of the Catalogue of the early type contact systems with period changes is presented.

Key words: Contact early binaries (CE-stars), low-massive detached systems (DS), semidetached systems (SDS), KW-type systems (KW), period change.

The important results about evolution of close binaries may be received from the study of change of orbital periods. Stellar wind, magnetic stellar wind (MSW), conservative transfer of matter, the loss of matter in surrounding area are the main reasons of period change.

In (Svechnikov, 1990) was made research of comparing of periods of DS and SDS (after role exchange). The majority of SDS have periods $P = 1-3$ days. The increasing of orbital period of SDS with decreasing of mass ratio take place. Many SDS, which evolves in "case A" transform to the contact configures, for example to CE-systems. By opinion of (Giuricin et al., 1984) the majority of observed CE-stars of the late spectral B- subclasses and A are formed from the more wide DS at first in process of the role exchange.

In (Kricheva et al., 1986) was shown that systems with mass fewer than 5 solar masses, whose secondaries have convective outer envelopes, lose the angular momentum due to MSW (SDS, CE, KW). In (Svechnikov, 1990; Fedorova and Tutukov, 1994) was noted that primaries of low-mass CE-stars ($M_1 1.5 M_{\odot}$) have radiative envelopes and their secondaries have convective envelopes. It helps to decreasing of distance between the components due to MSW. For example, SDS-systems of R CMa-type are the previous stage of low-massive CE-

stars. They have the "century" decreasing of orbital period.

The class of CE-stars presents a great interest regarding evolution of close binaries. CE-stars from Catalogue (Bondarenko and Perevozkina, 1997) have as decreasing as increasing orbital periods. According period change and a degree of filling of Roche-lobe of the components it is may to define what take place in system: is there a matter transfer from one component to other or mass loss with system?

MSW is a significant factor of decreasing of orbital period. The change of large semiaxis due to MSW according the law from (Scumanich, 1972) is presented in (Fedorova and Tutukov, 1994). The study of CE-stars with changing periods confirms that mass transfer in system and mass transfer to the second Roche-lobe with formation of the nearsystem gas structures are the main factors of the CE-stars evolution. Uncorresponding of observed and theoretical light curves demonstrates a presence of the gas streams in system. For low-massive CE-stars with increasing period due to mass loss of secondary MSW prevents from increasing of large semiaxis and orbital period.

As a result of abovementioned CE-stars are evolutionary unhomogeneous systems. Also great interest presents the class of KW-type. They may be formed from low-mass DS due MSW and following decreasing of orbital period. However, the union of KW components in one star is not observed. Is it possible that KW are evolutionary unhomogeneous class too? Are KW-stars future evolutionary stage of CE-systems?

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EVOLUTION OF THE PHOTOMETRIC PROPERTIES OF THE MAGNETIC CATAclySMIC BINARY QQ VUL IN 1986-88

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ABSTRACT. The long term activity variations of polar QQ Vul in 1986-88 are reported. Changes of the amplitude and the shape of phase eclipse curve are present. Moments of 20 minima are presented which are in a good agreement with the ephemeris by Andronov and Fuhrmann (1987, IBVS N 2976).

Keywords: Stars – binary, polars, Individual: QQ Vul

1. Introduction.

QQ Vul is one of the magnetic cataclysmic variables with relatively weak magnetic pole (20×10^6 MGs). QQ Vul was discovered as a polar by Nousek et al. (1984). They derived orbital period of $P \approx 222$ min. Long-term variability has been investigated by Andronov and Yavorskij (1983). McCarthy et al. (1986) investigated two emission regions in this system - from high speed gas in the accretion flow and from the heated face of the secondary star. Osborne et al. (1986) introduced soft X-ray observations, which show presence of the two brightness minima during the orbital period. This may be possibly explained as a two-pole accretion in this system. Mukai et al. (1986) determined physical properties of the components, and explained the dips at the light curves as eclipses of the combination of the cyclotron beaming and of the occultation of the inner part of the accretion column by its outer part. They also discovered γ -velocity changes. In the second half of the 1985 year, the soft X-Ray curve of QQ Vul radically changed (Osborne, 1987). Instead of two neighbor

minima, the new curve showed two unequal minima, separated by a half of period. Recently Cropper (1998) discussed week-to-week changes of the phase curve geometry, similar to our results.

2. Observations.

422 observations of QQ Vul were obtained in 1986–1988 at the Schmidt camera of the Abastumani Astrophysical Observatory by G.N.Kimeridze, I.L.Andronov, S.V.Kolesnikov and N.V.Poplavskaya (Andronov et al., 1989). All negatives were obtained during 20 nights and this material was an excellent one to obtain individual light curves. The photometric system are close to pg - the film A-500. The brightness of the comparison stars take from Andronov et al. (1983). The table of individual observations is acceptable via Internet (Halevin, 1997).

Observations were processed by the "Remove and Reduce" package (Halevin, 1996). For computing the value of the barycentric correction we took the spherical trigonometry formulae and the barycentric position expressions for the Earth in the cartesian coordinates (Soma et al., 1988).

We obtained 20 moments of minima, corresponding to the primary and secondary eclipses (Table 1, the O–C data are not listed for secondary minima). Elements are taken from Andronov and Fuhrmann (1987), where the phase zero corresponds to the photometric minima (1).

In Figure 1 we show the residuals O–C

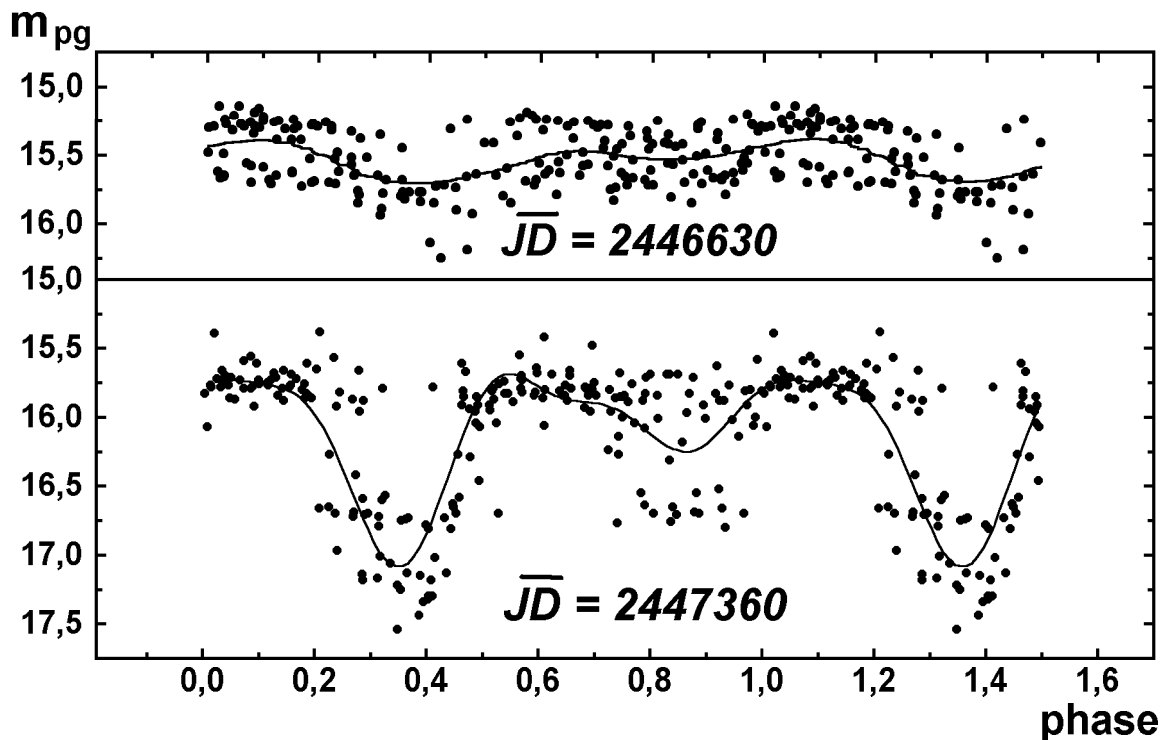


Figure 2. Phase curve of QQ Vul for two states.

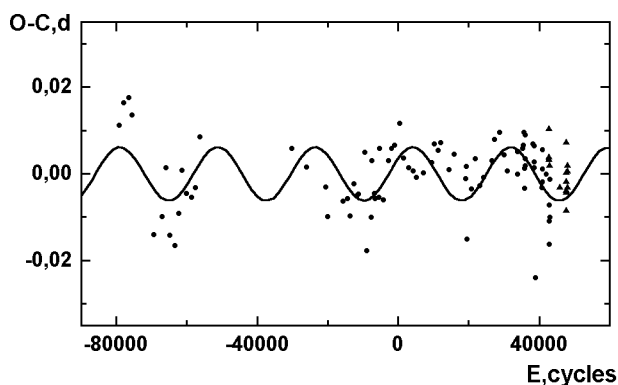


Figure 1. The O-C deviations for the primary minima of QQ Vul for the elements $HJD = 2440000.0628 + 0.154520356 \cdot E$. (1) (Andronov and Fuhrmann, 1987). The curve corresponds to their sine ephemeris.

for moments of minima corresponding to this ephemeris and listed by Andronov and Fuhrmann (1987) (circles) and in Table 1 (triangles). Our points do not change the coefficients of the sine ephemeris by Andronov and Fuhrmann (1987) within their error estimates. The sine fit represents variations with some mean period and amplitude. Obviously, there are strong variations of both these parameters.

There are two photometric states of the acti-

vity with different amplitude of the variations (see unbinned phase light curves in Fig.2). In the more quiet phase the amplitude of phase curve is about $0.^m5 - 1.^m0$ during our 3 week observations in the 1986 year. In 1987 and in 1988, the brightness amplitude is about $1.^m5$. There is some dependence between the magnitude at maximum and the amplitude of the brightness variations (correlation coefficient $r = 0.723$, $r/\sigma_r = 3.6$, Fig.3). One of the possible explanations is that the greater accretion rate causes a part of the accretion stream to penetrate the magnetosphere more deeply, than at lower accretion rates, before threading along magnetic lines. The 'footpoint' of these lines occurs therefore at different latitudes, and then the accretion region would be seen at different angles.

Phase of the primary and the secondary minima is 0.35 ± 0.02 and 0.86 ± 0.05 according to the ephemeris by Cropper (1998) for the pulses of linear polarization. These values are close to 0.40 and 0.85 derived by Cropper for the observations from July, 1983 to June, 1986.

Also possible a weak trend of the width and depth of the both minima. Day-to-day changes of the maximal brightness one can see in Fig.4.

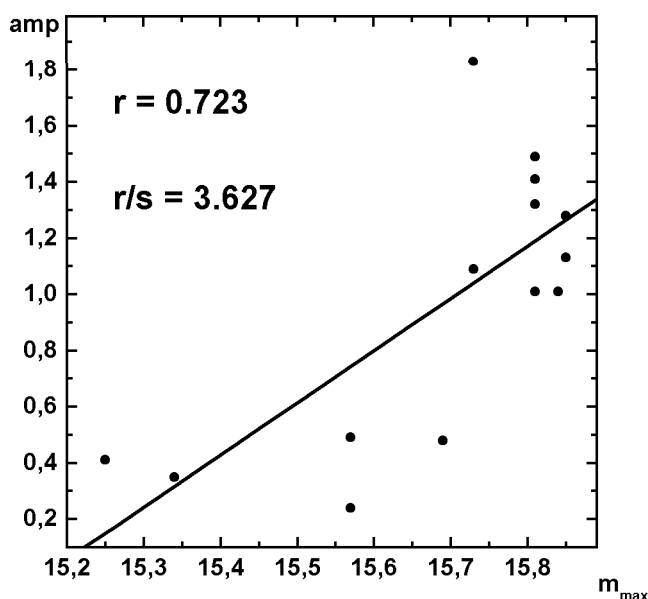
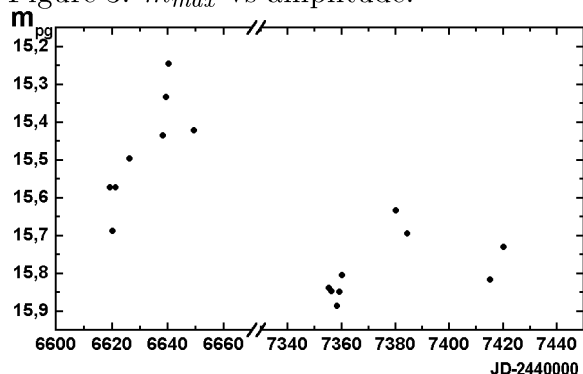
Figure 3. m_{max} vs amplitude.

Figure 4. Variations of the maximal brightness.

3. Conclusions.

We investigated the photometric activity of magnetic cataclysmic variable QQ Vul in period of 1986–88:

(i) the amplitude is variable within $0.^m5 - 1.^m5$, with changes of the maximal and minimal brightness, and the width of the primary and secondary minima;

(ii) the amplitude depends on the brightness at maximum nonlinearly, i.e. it is rather small for $m_{max} \leq 15.^m7$ and drastically increases for fainter states. One may note a year separation between the data in different states;

(iii) the variations of the phase of the mean primary eclipse may be explained by real changes of the accretion geometry in this system at times from days to years.

Table1.

HJD_{min}	σ_{min}	m_{min}	σ_m	O-C
6619.4089	0.0007	16.069	0.055	0.0031
6620.3431	0.0013	16.173	0.079	0.0102
6621.4182	0.0057	15.814	0.105	0.0037
6639.3407	0.0025	15.685	0.069	0.0017
6640.3381	0.0022	15.654	0.093	
7095.3253	0.0014	17.130	0.208	-0.0032
7355.3130	0.0061	16.429	0.272	
7355.3818	0.0015	16.853	0.121	-0.0045
7356.3205	0.0052	16.618	0.327	0.0072
7356.4680	0.0009	16.978	0.183	0.0001
7359.3189	0.0013	16.642	0.113	
7359.4018	0.0018	17.132	0.184	-0.0020
7359.4786	0.0017	16.410	0.157	
7360.3223	0.0027	16.818	0.229	-0.0086
7360.4064	0.0052	16.494	0.290	
7360.4814	0.0010	17.300	0.161	-0.0041
7415.4067	0.0044	16.501	0.209	
7418.4273	0.0017	17.226	0.263	-0.0032
7420.2866	0.0025	16.819	0.324	0.0018
7420.4398	0.0003	17.558	0.104	0.0004

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ANGULAR MOMENTUM CHANGES IN ECLIPSING BINARY STARS OF DIFFERENT TYPES

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ABSTRACT. Based on the characteristics on 303 eclipsing binary stars we calculated the angular moments and those dependence from the stellar masses. We got the clear correlations, when divided the stars on the groups with different masses and orbital periods. It was shown, that the angular moment successively decreases during passing from MS- through CE- towards to SD- system stars, and increasing the speed of changes. The maximal values of changes of the speed of changes was found for systems of small masses and periods. It was discussed the unsingle dependence in CE systems of small masses and periods.

Key words: Stars: binary, statistics, evolution

Up to the present time, the theory of the eclipsing binary systems evolution has been confirmed observationally. Generally, the theoretical predictions quite well agree with observational data (Masevich and Tutukov, 1988). In particular, it was shown that angular momentum of the close binaries decreases from MS systems (detached systems of the main sequence) toward the SD systems (semi-detached systems with subgiant) (Svechnikov, 1969). Taking into account that conception of the transition from one group of binary systems to another group is regarded to be established, one can state that comparing the angular momentum values for different stellar groups, we can understand the principal tendencies of the close binaries evolution.

The angular momentum values $\lg H$ have the natural distribution and vary within the large interval from 1.5 to 4.0. For MS systems $\lg H$ value is clearly proportional to the common mass $\lg M$ of system with the coefficient 1.85,

while for SD systems some distortion of the dependence takes place with clear decreasing of the angular momentum comparably to MS systems. The difference between angular momentum values increases with the decreasing of the mass ratio parameter q . Comparison with angular momentum values for DS does not show any decreasing of those values. Perhaps, this fact testifies about differences in the mass transfer and mass loss processes which decrease the angular momentum.

Angular momentum decreasing indicates also non-conservative case in the mass transfer process. For example, in (Popov, 1970) it is shown that mass loss from the systems with primary of $10M_{\odot}$ can achieve 75 % of its mass and 90 % of this material leaves the system. Now, the estimates of mass loss rate are available for binary systems of the different masses. Therefore, it is necessary to take into account not only the differences in the mass ratio for different systems, but also the differences of full masses $M = M_1 + M_2$ (where M_1 - is mass of more massive star). It is important, because mass loss rate is linked with the general characteristics of binary systems.

The observations show that binary systems lose an angular momentum due to stellar and magnetic wind (like single stars do), and angular momentum can also be lost due to specific mechanisms operating only in close binary systems - gravitational radiation and mass transfer between components. Gas flows play a key role in the mass loss from binary systems. Accordingly to observational data, they can lead to mass loss up to $10^{-4}M_{\odot}/\text{yr}$. Other mechanisms give more modest contribution in the mass loss process. For ordinary binary systems, the gravitational effect are negligible.

They should be taken into account only for very short-period objects.

One can state that at the present time very accurate observational data on the parameters of close binary systems are collected in the literature. The most accurate data are presented in (Popper, 1980), where some values have an accuracy of about of 3 %. Using the more complete catalogue (Svechnikov, 1986), one can expect to have an accuracy of about 15 %. We used the catalogue (Karetnikov and Andronov, 1989) for the determination of the angular momentum in close binaries. First of all we divided all systems on the groups taking into account their masses and orbital periods.

The groups were the following:

"a" - close binaries with $M_1 < 1.5M_\odot$ and $M_2 < 1.5M_\odot$. Stars possess the magnetic wind. A role of an usual stellar wind in this case is negligible.

"b" - masses are: $1.5 < M_1 < 10M_\odot$ and $M_2 < 1.5M_\odot$. Secondary component possesses magnetic wind, but primary does not. A role of usual stellar wind is still negligible. For primaries and some massive secondaries, the nuclear evolution is important.

"c" - both stars have the masses between $1.5M_\odot$ and $10M_\odot$. Magnetic stellar wind is absent. Usual stellar wind is not important. The evolution of binary system is mainly caused by nuclear reactions.

"d" - the mass of primary is $M_1 > 10M_\odot$, secondary - $M_2 > 1.5M_\odot$. Usual stellar wind is important for evolution, as well as nuclear reactions (in first place for secondary).

Further dividing of these groups on subgroups we performed separately for binary systems consisting of the main-sequence components (MS, $\sim$ CW, CW, CE) and systems with subgiant (SD, DS, AR). In the first case the dividing was the following: subgroup 1a - systems of group "a" with orbital period $P < 2.5^d$; subgroup 2a - periods are from 2.5^d to 3.5^d ; subgroup 3a - $P > 3.5^d$. Similar designation were also adopted for groups "b", "c", "d". For systems of SD, DS and AR, more detailed specification was used: 1a - $P < 1.5^d$; 2a - $1.5 < P < 2.5^d$; 3a - $2.5 < P < 3.5^d$; 4a - $3.5 < P < 6^d$; 5a - $P > 6^d$ and

similarly for groups "b", "c", "d" of the binary systems with subgiant star.

Results of calculation are gathered in Tables 1 - 3, where for each group or subgroup one can find the total number of systems belonging to considered group and coefficients A and B of the linear formula " $\lg H = A + B \cdot \lg M$ " with the significance level of the correlation more than 0.95. For determined coefficients A and B we give sigma values $\sigma(A)$ and $\sigma(B)$. Here also the coefficient of correlation K and corresponding $\sigma(K)$ values are presented. It should be noted that correlation coefficients for groups CE-a and CE-b of low-mass contact system are less reliable. Coefficient of correlation for group MS-b is unexpectedly small (0.74). Other stellar groups show significant correlations.

Our calculations demonstrate the successive decreasing of the angular momentum from MS systems through CE systems and then to SD systems. The rate of of angular momentum decreasing (coefficient B) is smallest for MS and largest for SD systems. This confirms the conclusion made by us previously about the direction of the evolutionary changes: MS - CE - SD, even in spite of some increasing of the mean mass of stars from CE group. This schematic picture is also valid for "a" and "b" groups. For "c" group, the definite conclusion is difficult to draw. In "d" group, the masses and angular momentum values are increasing from MS trough CE to SD systems. It can be considered as a result of distribution on the masses and mechanisms of mass transfer and angular momentum.

Small values of the correlation coefficients in subgroups CE-a (0.70) and CE-b (0.74) significantly increase after performing the dividing on orbital periods. Perhaps it can be explained by the merging effects in short-period low-mass CE-a and CE-b systems caused by magnetic stellar wind operation, like in CW systems (Karetnikov, 1997), while wide pairs escape the coalescence. As it follows from Table 2, more detailed classification shows different behaviour of angular momentum with mass variation (see B coefficients). Probably, it is indirect confirmation of hypothesis about differences of the evolutionary processes

Table 1. N - number of systems, full masses $\lg M$, angular momentum $\lg H$ values, coefficients A and B of formula " $\lg H = A + B \cdot \lg M$ " and correlation coefficients with sigma values $\sigma(A, B, K)$ for MS systems.

Name of group	N	Main values		Coefficients		
		$\lg M$	$\lg H$	A	B	K
MS-75 σ	75	0.75	2.71	2.19	0.69	0.94
		0.36	0.27	0.02	0.03	0.04
MS-a	14	0.32	2.42	2.11	0.96	0.94
		0.20	0.21	0.04	0.10	0.10
MS-1a	4	0.12	2.17	2.08	0.75	0.98
		0.30	0.23	0.03	0.11	0.14
MS-2a	4	0.40	2.49	2.10	0.96	0.99
		0.03	0.03	0.03	0.08	0.08
MS-3a	5	0.40	2.56	1.89	1.71	0.91
		0.04	0.07	0.17	0.44	0.23
MS-b	13	0.54	2.57	2.04	0.98	0.52
		0.05	0.10	0.26	0.48	0.26
MS-1b	6	0.53	2.50	2.18	0.59	0.81
		0.05	0.03	0.10	0.21	0.29
MS-2b	3	0.52	2.54	2.08	0.91	0.94
		0.03	0.03	0.18	0.34	0.35
MS-3b	4	0.57	2.70	2.50	0.34	0.27
		0.06	0.08	0.50	0.86	0.68
MS-c	37	0.81	2.74	2.28	0.57	0.80
		0.19	0.14	0.06	0.07	0.10
MS-1c	18	0.86	2.71	2.21	0.58	0.96
		0.16	0.10	0.04	0.04	0.07
MS-2c	6	0.77	2.72	2.17	0.70	1.00
		0.19	0.13	0.02	0.03	0.04
MS-3c	13	0.74	2.80	2.24	0.74	0.95
		0.20	0.16	0.06	0.08	0.10
MS-d	10	1.41	3.18	2.57	0.44	0.56
		0.10	0.08	0.32	0.23	0.29
MS-2d	4	1.46	3.18	2.06	0.77	0.98
		0.06	0.05	0.16	0.11	0.14
MS-3d	5	1.36	3.20	2.28	0.67	0.77
		0.11	0.10	0.43	0.32	0.37

Table 2. N - number of systems, full masses $\lg M$, angular momentum values, coefficients A and B of formula " $\lg H = A + B \cdot \lg M$ " and correlation coefficients with sigma values $\sigma(A, B, K)$ for $\sim$ CW, CW and CE systems.

Name of group	N	Main values		Coefficients		
		$\lg M$	$\lg H$	A	B	K
$\sim$ CW σ	7	0.27	2.18	2.02	0.58	0.96
		0.11	0.07	0.02	0.08	0.12
CW-25	25	0.23	2.04	1.87	0.76	0.96
		0.13	0.10	0.01	0.04	0.05
CW-a	7	0.23	2.08	1.92	0.67	1.00
		0.16	0.11	0.01	0.02	0.03
CW-b	18	0.23	2.03	1.84	0.81	0.98
		0.12	0.10	0.01	0.04	0.05
CE-89	89	0.80	2.54	1.82	0.90	0.93
		0.49	0.47	0.04	0.04	0.04
CE-a	8	0.28	2.13	2.12	0.03	0.03
		0.09	0.10	0.12	0.42	0.41
CE-1a	4	0.27	2.05	2.11	-0.24	-0.42
		0.11	0.06	0.11	0.37	0.64
CE-2a	4	0.29	2.22	2.09	0.43	0.87
		0.06	0.03	0.05	0.17	0.34
CE-b	38	0.44	2.21	1.96	0.56	0.27
		0.08	0.17	0.15	0.33	0.16
CE-1b	26	0.42	2.24	1.90	0.81	0.44
		0.08	0.14	0.14	0.34	0.18
CE-2b	12	0.53	2.19	1.51	1.28	0.68
		0.14	0.25	0.22	0.41	0.22
CE-c	18	0.86	2.55	1.74	0.93	0.66
		0.21	0.29	0.24	0.26	0.19
CE-d	24	1.50	3.18	1.81	0.91	0.85
		0.24	0.26	0.18	0.12	0.11

Table 3. N - number of systems, full masses $\lg M$, angular momentum values, coefficients A and B of formula " $\lg H = A + B \cdot \lg M$ " and correlation coefficients with sigma values $\sigma(A,B,K)$ for systems with subgiants.

Name of group	N	Main values		Coefficients		
		$\lg M$	$\lg H$	A	B	K
AR-12	12	0.42	2.54	2.33	0.49	0.67
σ		0.10	0.07	0.07	0.17	0.23
AR-a	10	0.39	2.52	2.43	0.23	0.26
		0.06	0.05	0.12	0.30	0.34
DS-11	11	0.51	2.74	2.46	0.55	0.83
		0.19	0.13	0.07	0.12	0.19
DS-b	9	0.47	2.74	2.08	1.39	0.80
		0.06	0.10	0.18	0.39	0.22
SD-82	82	0.61	2.60	2.11	0.80	0.94
		0.32	0.27	0.02	0.03	0.04
SD-a	6	0.26	2.23	2.24	-0.04	-0.03
		0.05	0.06	0.17	0.64	0.50
SD-1a	4	0.26	2.19	2.16	0.09	0.24
		0.05	0.02	0.07	0.24	0.69
SD-b	58	0.50	2.52	2.15	0.76	0.77
		0.14	0.14	0.04	0.08	0.08
SD-1b	12	0.44	2.36	2.06	0.69	0.91
		0.09	0.07	0.05	0.10	0.13
SD-2b	10	0.50	2.47	2.13	0.68	0.98
		0.13	0.09	0.03	0.05	0.07
SD-3b	17	0.48	2.52	2.20	0.68	0.99
		0.14	0.09	0.01	0.03	0.04
SD-4b	12	0.56	2.63	2.29	0.61	0.98
		0.19	0.12	0.02	0.04	0.06
SD-5b	7	0.50	2.69	2.39	0.60	0.94
		0.13	0.08	0.05	0.10	0.16
SD-c	12	0.90	2.80	1.90	0.99	0.85
		0.08	0.09	0.18	0.19	0.17
SD-d	6	1.46	3.31	2.33	0.67	0.82
		0.18	0.14	0.34	0.23	0.28

in low-mass CE systems.

Unfortunately, it is not possible to perform an analysis using all the types of eclipsing binaries, because of scarcity of reliable observational material for some types. For example, there are only 7 systems of CW type, 11 systems of DS type, group DS-b contains 9 sys-

tems. AR type (12 systems, where both components are subgiants) forms AR-a subgroup (10 systems). Each of two DS and AR groups contains only one system. There is very small number of stars in W UMa (CW systems) type, where one can select only two groups. In addition, we excluded from the analysis some binary systems with strongly deviating characteristics.

Thus, more reliable analysis of the evolutionary changes in close binary systems should be based on the investigation of angular momentum values for different groups. It should be also mentioned that distribution of the systems on their masses gives us an information about the evolutionary changes and possibility of the increasing of massive stars number on some evolutionary stages. Probably, it could explain the peculiarities observed in massive systems of "d" group (among the MS systems there are less massive stars than in CE systems). Generally, our results confirm the adopted hypotheses about binary stars evolution.

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LONG-TERM ACTIVITY CHANGES OF UV PISCUM

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ABSTRACT. UV Psc has been observed since 1976 at the Ankara and Ege University Observatories. Mean light curves in B and V colours obtained using the maxima levels of observed light curves of the system. Assuming this light curves as the least active ones, the orbital parameters of the system have been obtained using the Wilson–Devinney code. The radial velocity curves of both components have been used during the solution. Wave-like distortion curves for each year have been obtained subtracting the theoretical light curves from the observed ones. Using these curves, the spot parameters have been roughly determined and finally, spotted light curve solutions and the accurate spot parameters have been obtained. Activity and colour behaviour were examined.

Key words: Stars: binaries: close-stars: individual (UV Psc) - stars: variable

Introduction

Chromospherically active RS CVn type eclipsing binary UV Psc (BD +6°189) has been observed since 1976 at the Ankara and Ege University Observatories. It shows wave-like distortions in its light curves like other RS CVn systems. These systems have variable mean-brightness and period.

All the data obtained at both observatories were transformed to standard UBV system and combined. During the observations BD +06°191 and BD +06°197 were used as comparison and check stars, respectively. In Figs. 1 and 2, all the data obtained at both observatories are given. The maxima of the light curves are seen as a thick band due to the mi-

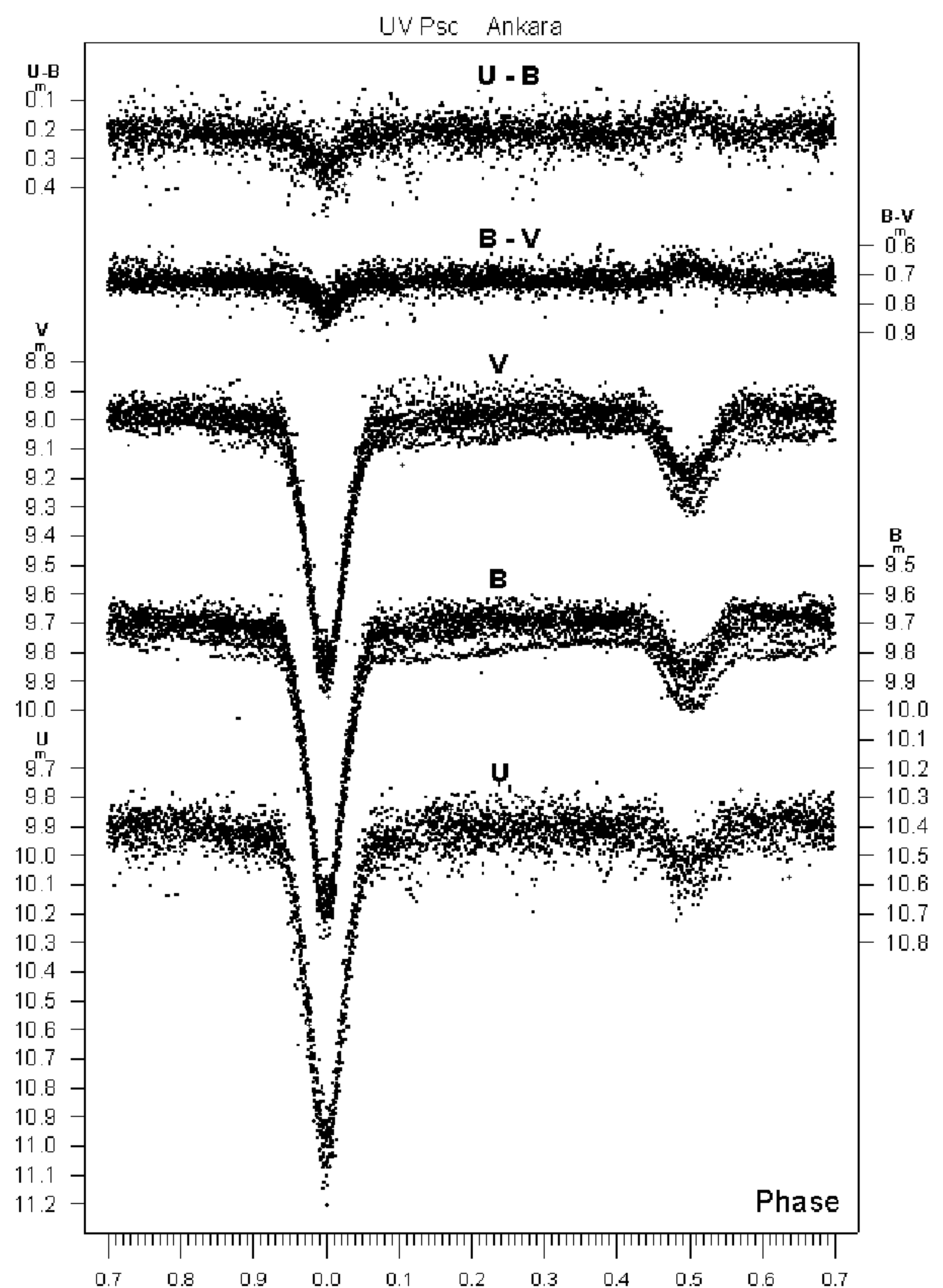


Figure 1: U, B and V light curves of UV Psc obtained at the Ankara University Observatory.

gration of the wave-like distortion. Because the position of the maximum and minimum of this distortion are in different phases in each years' light curve.

In this study, our aim was to analyze the light curves of the system in B and V colours and to determine the positions of the spots caused the wave-like distortions of light curves. If one can determine the spot parameters on one of the component star's surface, activity cycle of the system can be determined if it has any periodicity. If the orbital parameters of the sy-

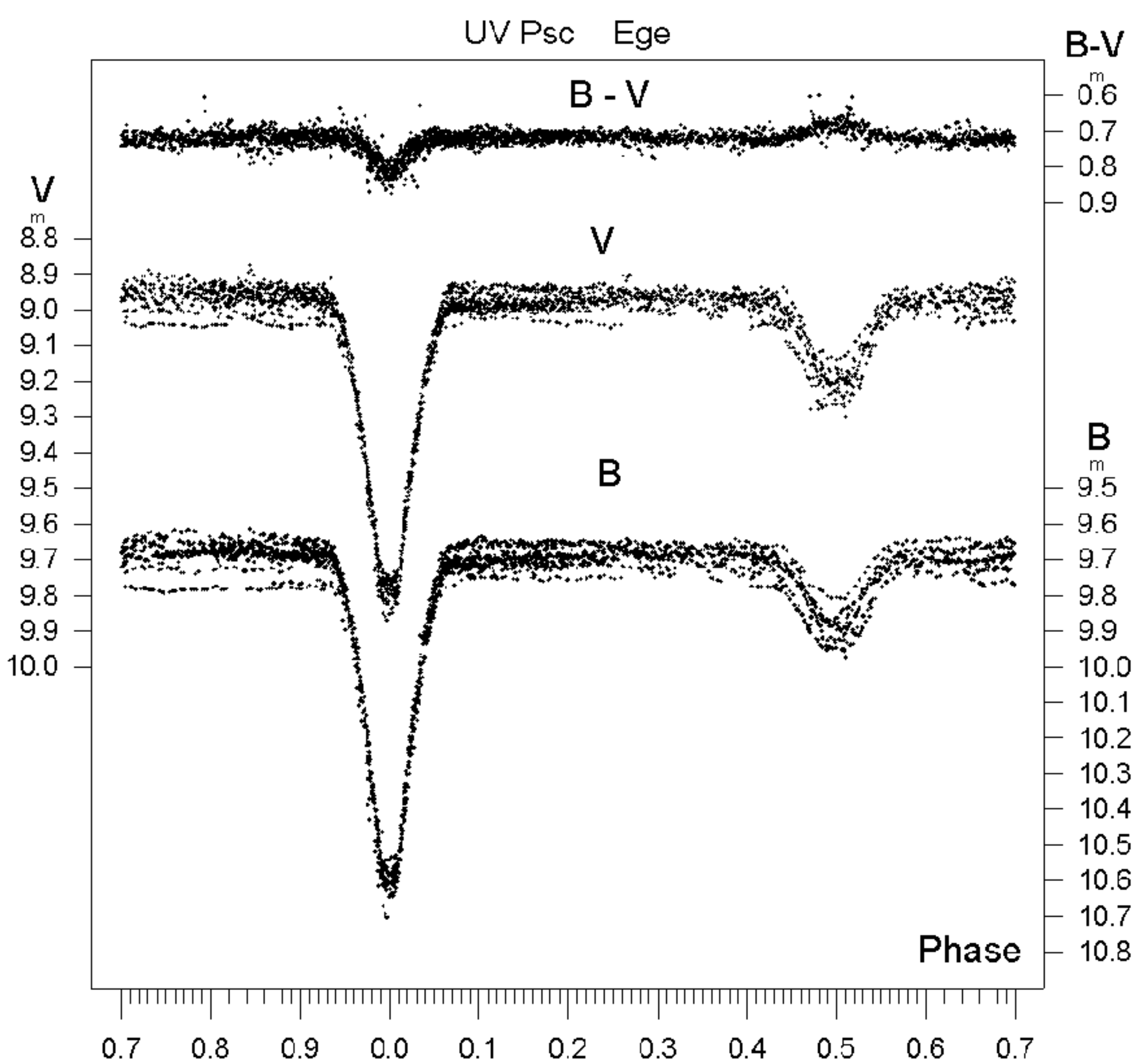


Figure 2: U, B and V light curves of UV Psc obtained at the Ege University Observatory.

stem are known, the theoretical light curve can be calculated, and subtracting this light curve from the observations, parameters for the activity and variation can be determined from these differential curves.

Light Curve Solution

Generally, one or more spots are located on one of the components (generally on cool component) of RS CVn type systems and they changes with time. Effects of these spots generally are seen at the maxima of light curves. So, the shape of each obtained light curve is different from the others. In order to determine the activity of the system, first of all, eclipses and the proximity effects should be known. This can be done only determining the orbital parameters of the system solving the light curves.

In order to compare each light curves to others, the average brightnesses have been calculated for every 0.01 phase interval for V colour. The maximum brightness values were selected for each phase and the light curve was folded at the 0.5 phase in order to guarantee each point is really the brightest one for each phase value. These values were used as the mean light curve. We supposed that this light curve is the least active one. This procedure was also repeated for B colour.

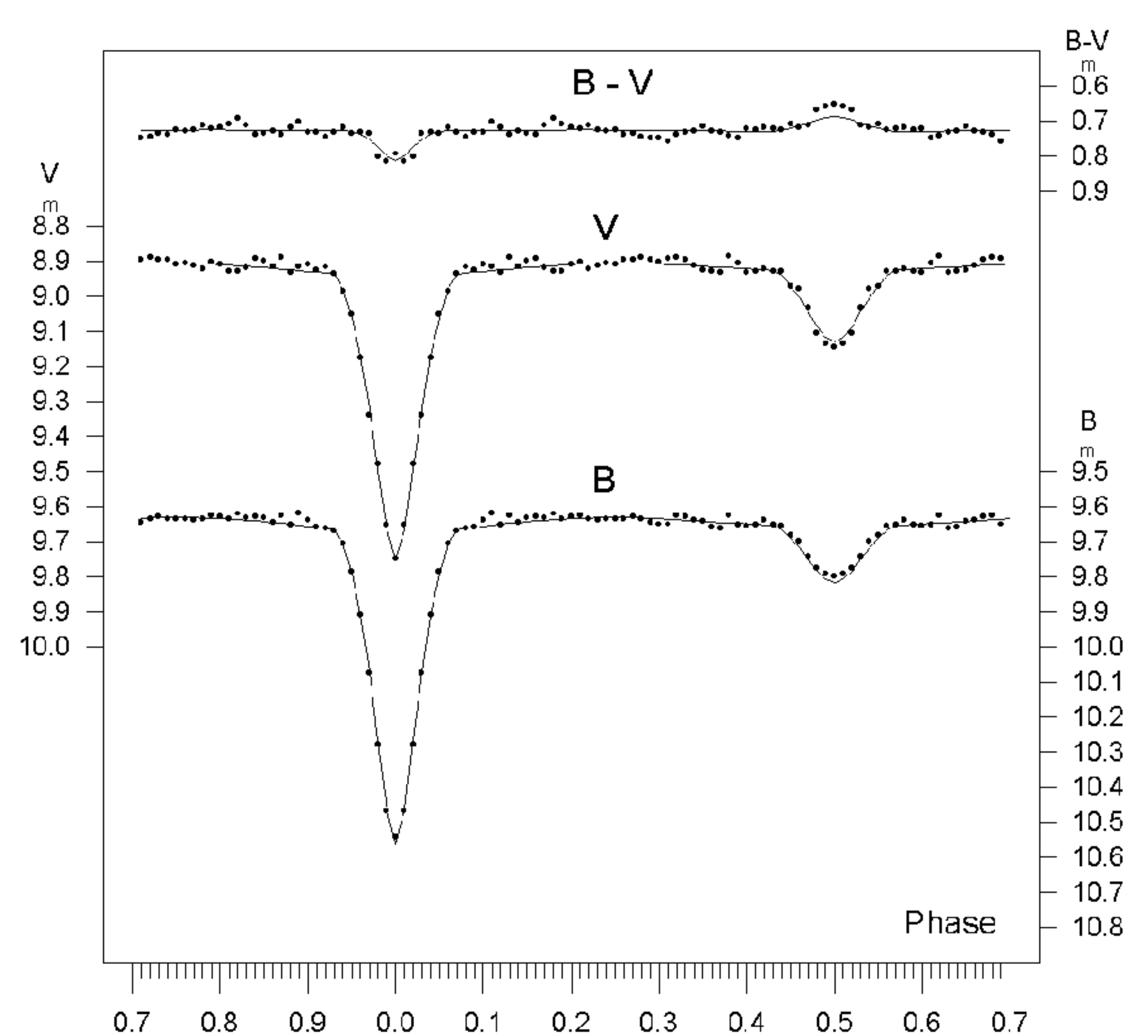


Figure 3: B and V mean light curves and B–V mean colour curve of UV Psc. Theoretical curves are also drawn onto the observed curves.

If a light curve is obtained without the spots (or if this obtained light curve is not affected by the spots), orbital parameters of the system can be determined but such a light curve never could be obtained. Because the activity of these systems are never disappearing. In this case, The least active mean light curve should be supposed as if it has no activity. Otherwise, if we do not make such an approximation, nothing can be determined about the activity of the system and the spots.

For the light curve solution with the Wilson–Devinney code (Wilson and Devinney, 1971), various parameters for the system were collected from the literature and some parameters determined in this study. Radial velocity curves for both components which obtained by Popper (1991) were used. During the solution, only the presence of the proximity and reflection effects were assumed. Table 1. shows the some initial and determined parameters of the system.

With the determined parameters, the theoretical light curves of the system were calculated and drawn with the observed mean B and V light curves in Fig. 3. The B–V colour curve is also included in the figure. These theoretical curves were subtracted from the observed light curves of each year and the vari-

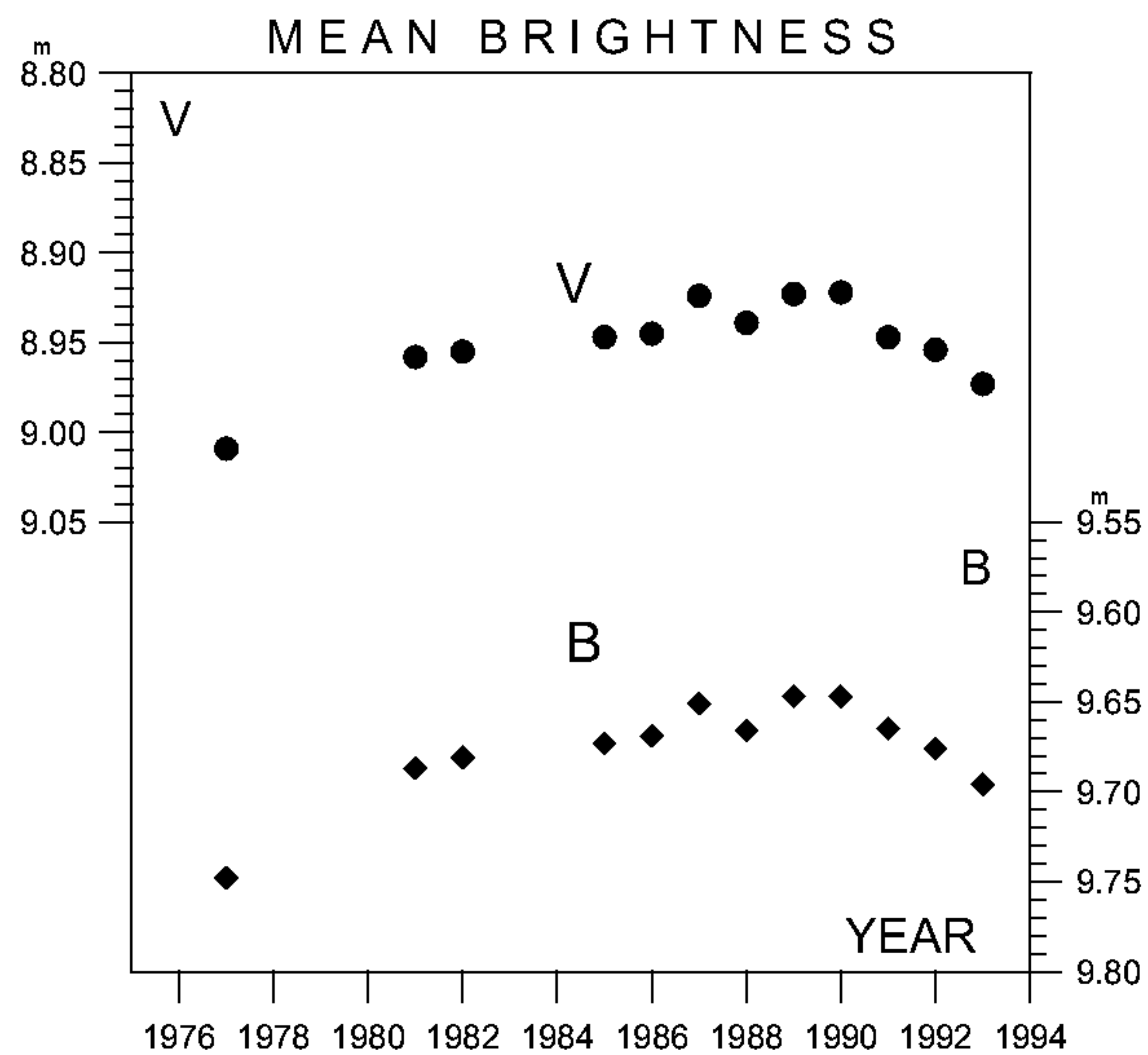


Figure 4: B and V mean brightness versus time.

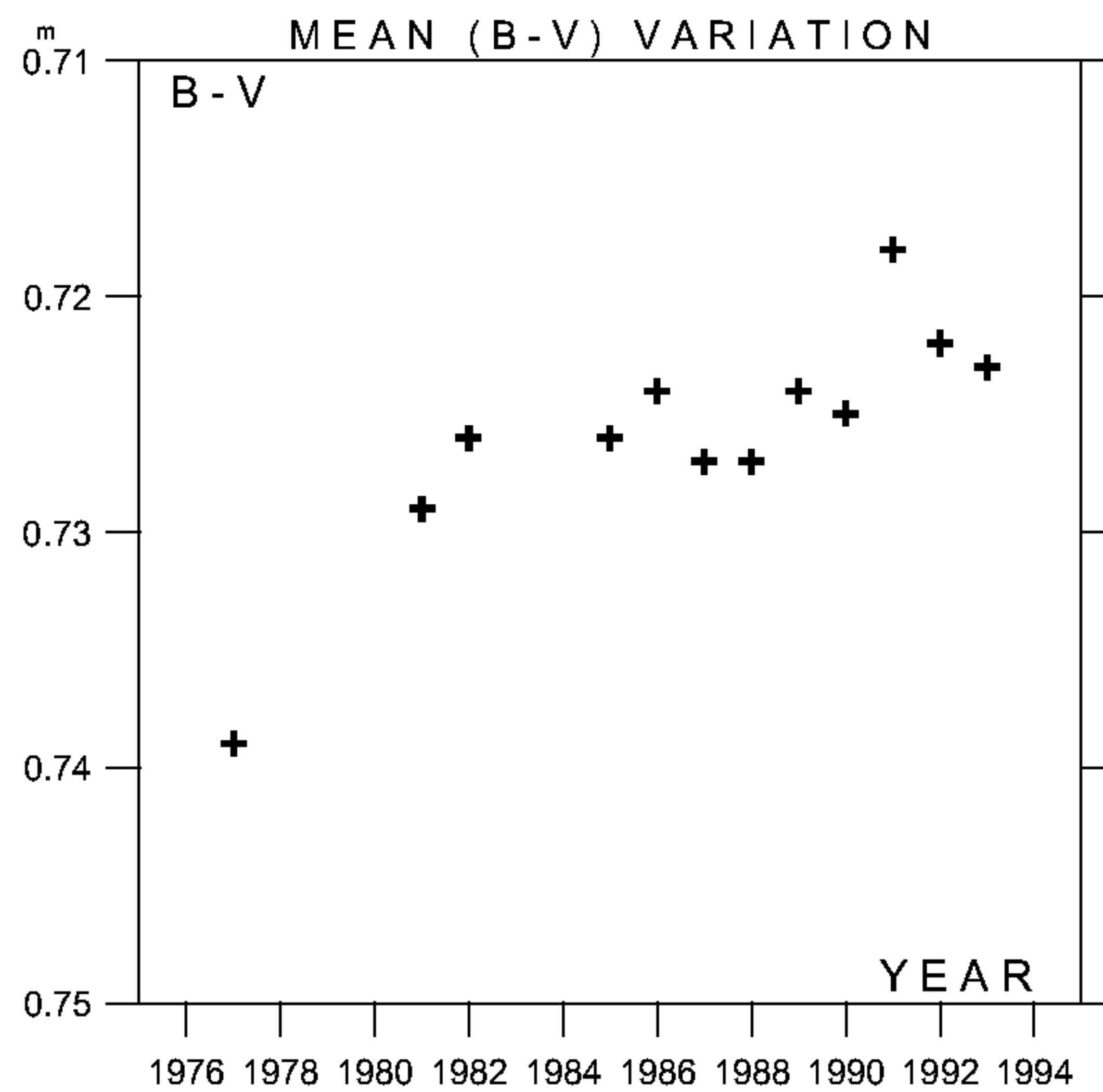


Figure 5: B-V mean colour versus time.

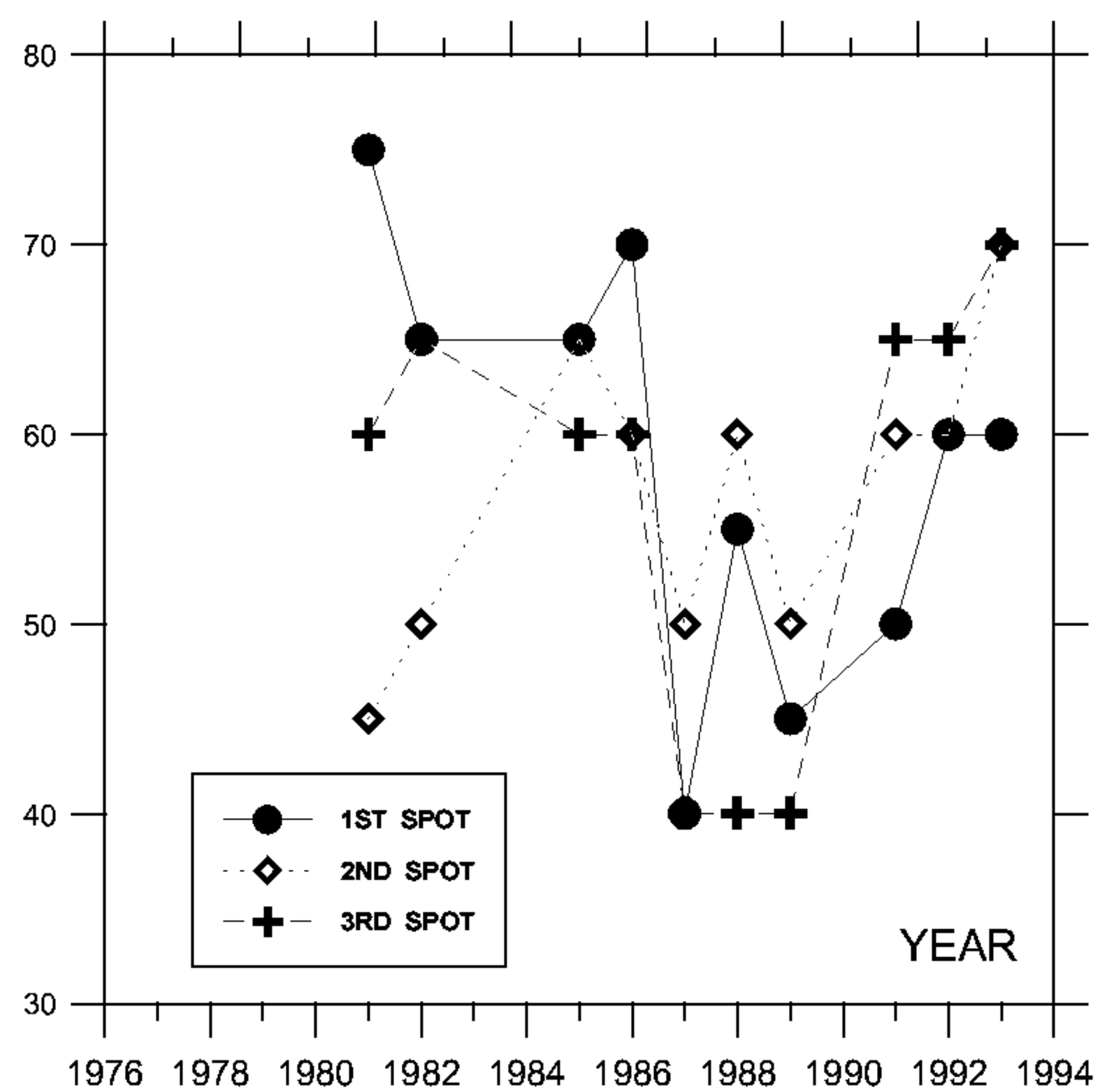


Figure 7: Latitudes of the spots versus time.

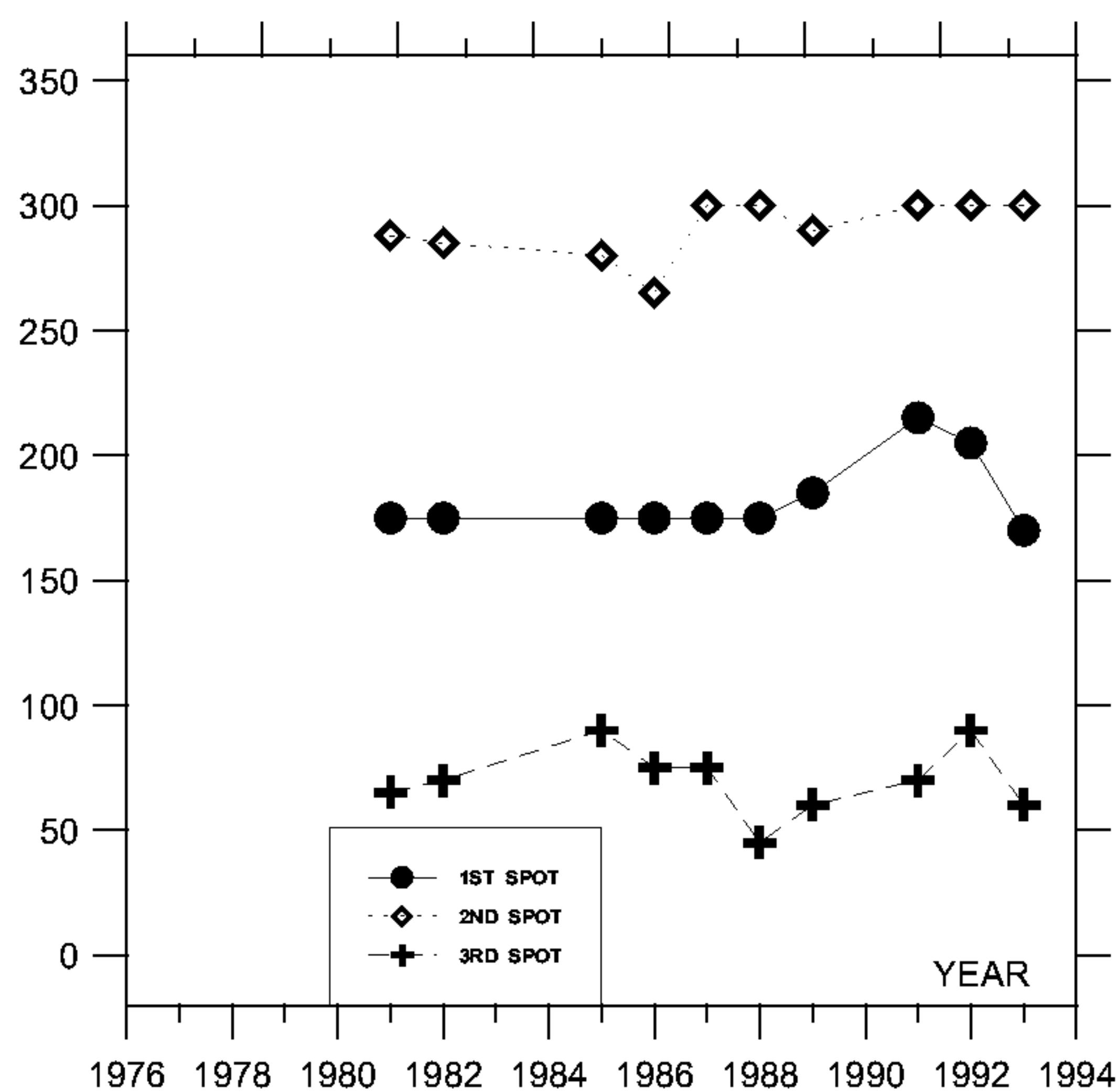


Figure 8: Longitudes of the spots versus time.

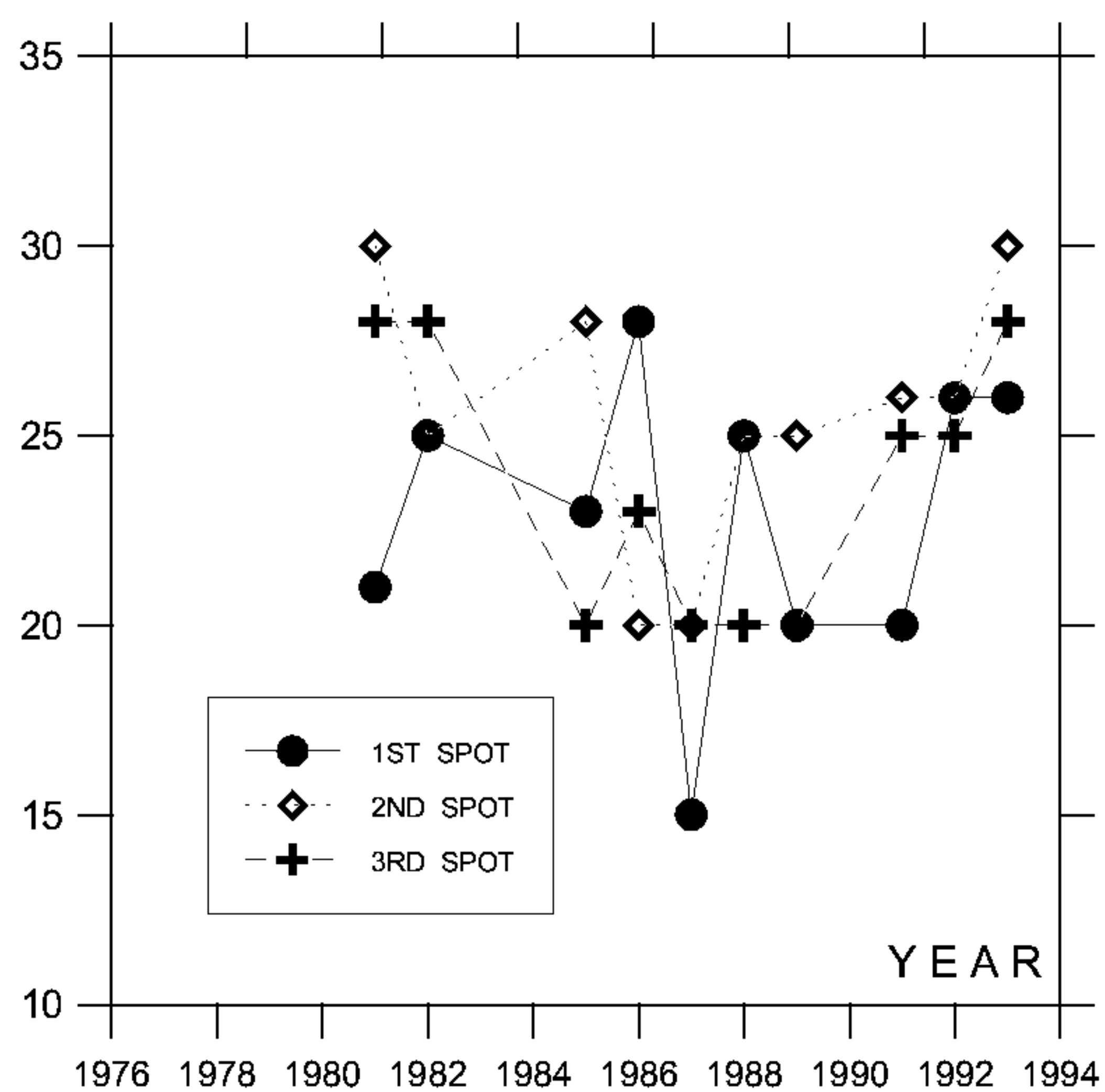


Figure 6: Radius of three spots versus time.

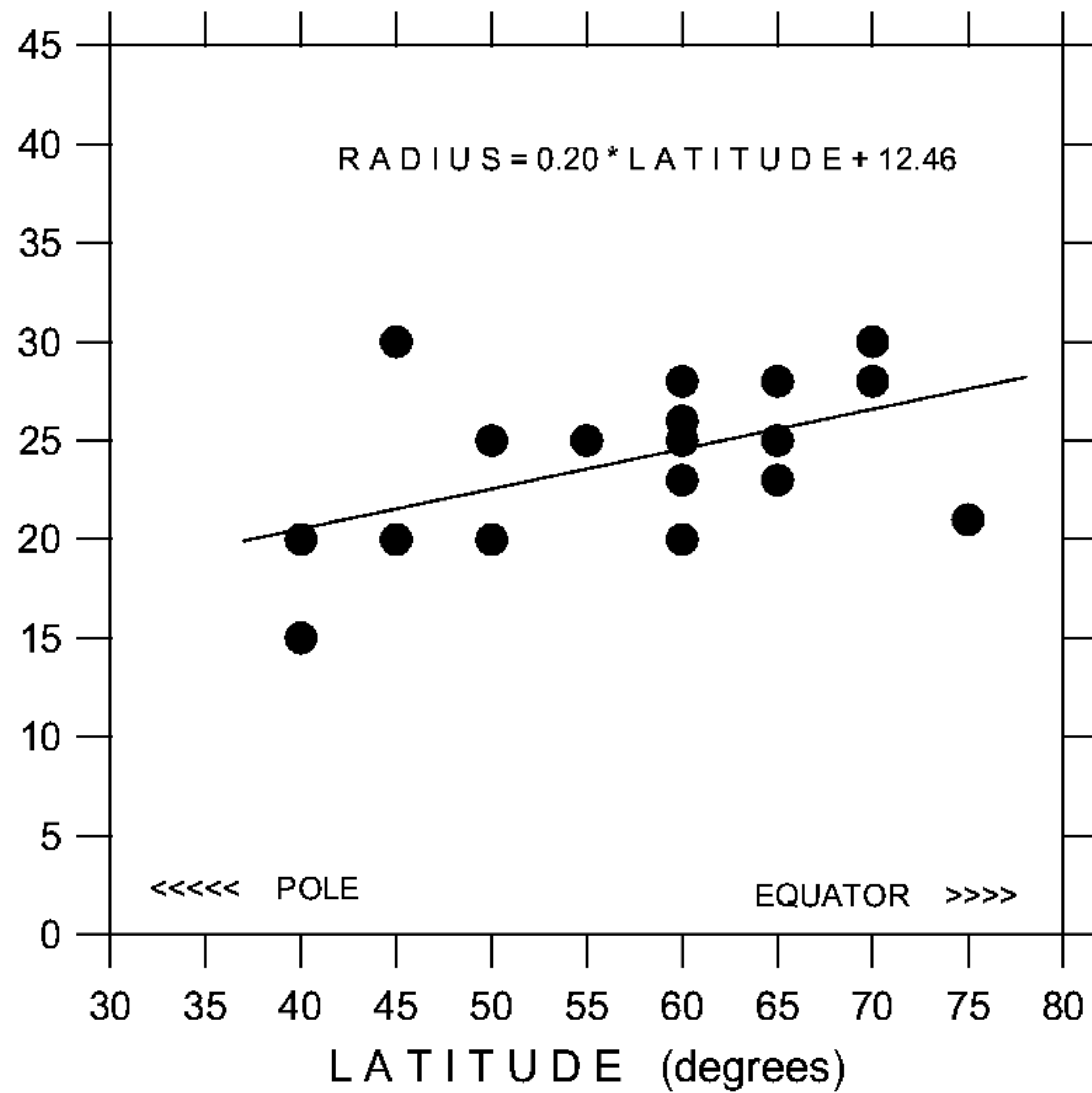


Figure 9: Radius of the spots versus latitudes of them.

Parameter	Initial Value	Final Value
T_h	5740	
T_c	4750	4555 ± 10 K
i	88°	$85^\circ 310 \pm 0.099$
q (m_c/m_h)	0.768	
$l_h(B)$		0.872 ± 0.024
$l_h(V)$		0.836 ± 0.025
$l_c(B)$		0.128 ± 0.024
$l_c(V)$		0.164 ± 0.025
r.m.s.		0.00376

Table 1: Some initial and final parameters of UV Psc used in the light curve solution.

ations of the wave-like distortion curves were determined for each year. Assuming the reason of this distortion is one or more spots on one of the components, the numbers, longitudes, latitudes and temperature factors of the spots were roughly determined using these wave-like distortion curves. Using these initial parameters for the spots, the light curve solution of the system repeated and the final spot parameters determined.

Conclusions

UV Psc have been observed for a long time photoelectrically by many investigators but spectroscopic observations are very rare. For a unique light curve, it is very difficult to obtain the maximum light level in order to determine the spot activity. In this study, this was not so difficult since we have 18 years of observations. Figs. 4 and 5 show that the system shows a periodic mean brightness and colour variation. The period of this variation is approximately 8 years.

Fig. 7 shows that while the latitudes of three determined spots change during the activity cycle and the spots migrate to equator until 1988 and then they migrate to pole, the longitudes of these spots almost remain constant. During the cycle, the radius of these spots also change (Figs. 6, 7) but the periodicity of this change is not similar to latitude change period.

It is necessary to obtain long-term and high

resolution spectra of the system in order to support these photometric results. Despite lack of such spectral data, the orbital parameters and the activity changes of the system were determined with sufficient accuracy since we have long-term observations of the system. Future observations of the system will make these results more accurate.

Acknowledgments. The authors are thankful to TÜBİTAK (Scientific and Technical Research Council of Turkey) supporting this study.

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PHOTOGRAPHIC OBSERVATIONS OF ECLIPSING BINARY AL OPH

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ABSTRACT. Photographic observations of AL Oph are discussed. Five moments of minima are listed.

Key words: Stars: eclipsing; individual: AL Oph.

AL Oph was measured on the plate collection of the Shternberg State Astronomical Institute (Moscow). Finding chart is shown at Fig. 1. The magnitudes of the comparison stars were obtained photographically by using the iris-photometer.

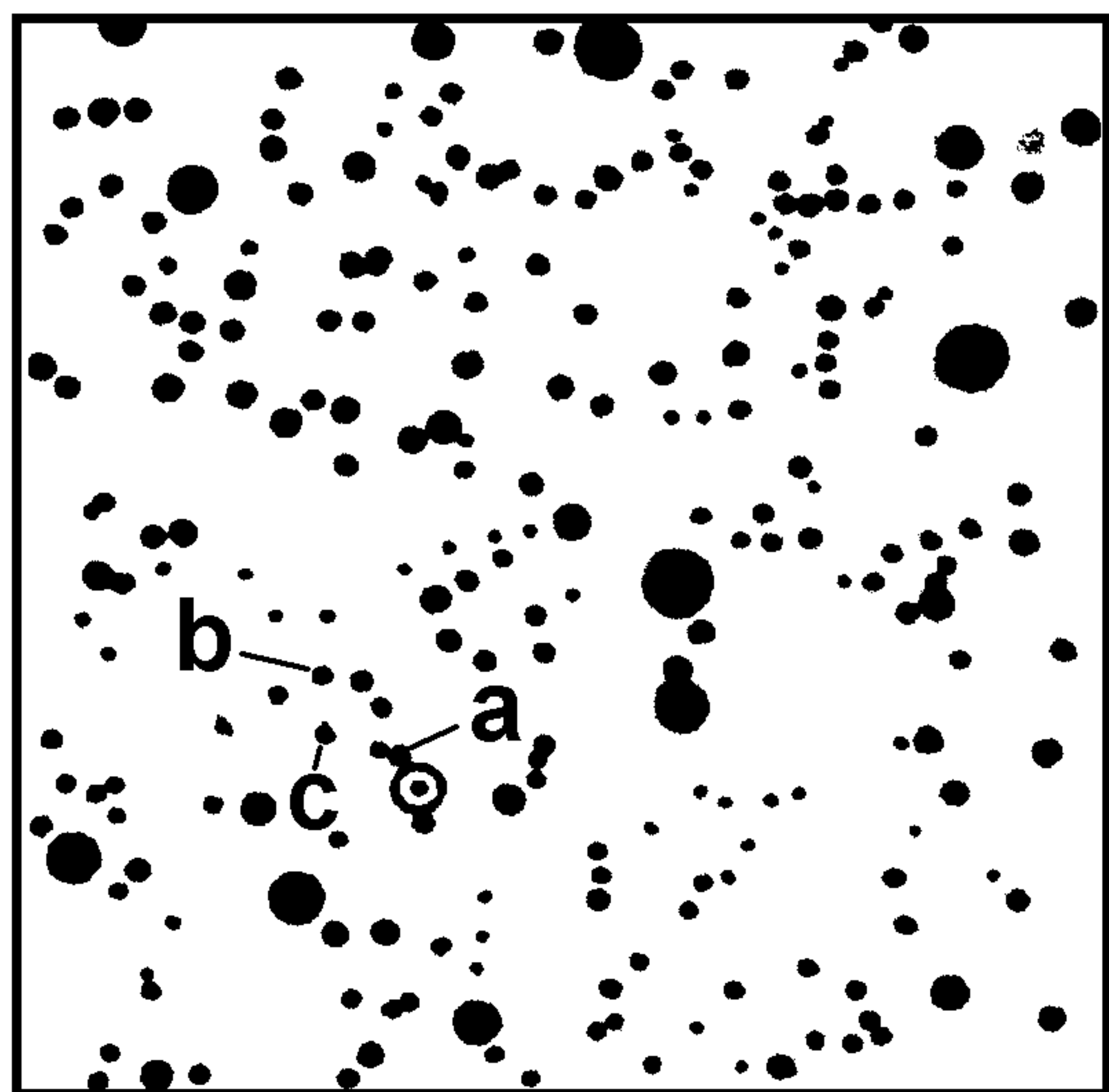


Figure 1. Finding chart for AL Oph. Magnitudes of the comparison stars: $a = 14.60$; $b = 15.10$; $c = 15.41$

Orbital period of system is close to 1^d and this fact produce difficulty of its definition. Šarounova and Wolf (1997) have found elements

$$JD2450243.4348 + 0.993005 \cdot E$$

using photoelectric observations. We have

Table 1. Moments, magnitudes and phases of minima

$JD24.....$	m	ϕ
34131.478	15.05	0.545
36341.422	15.11	0.058
36422.354	15.08	0.559
36504.292	15.01	0.074
48390.524	15.22	0.037

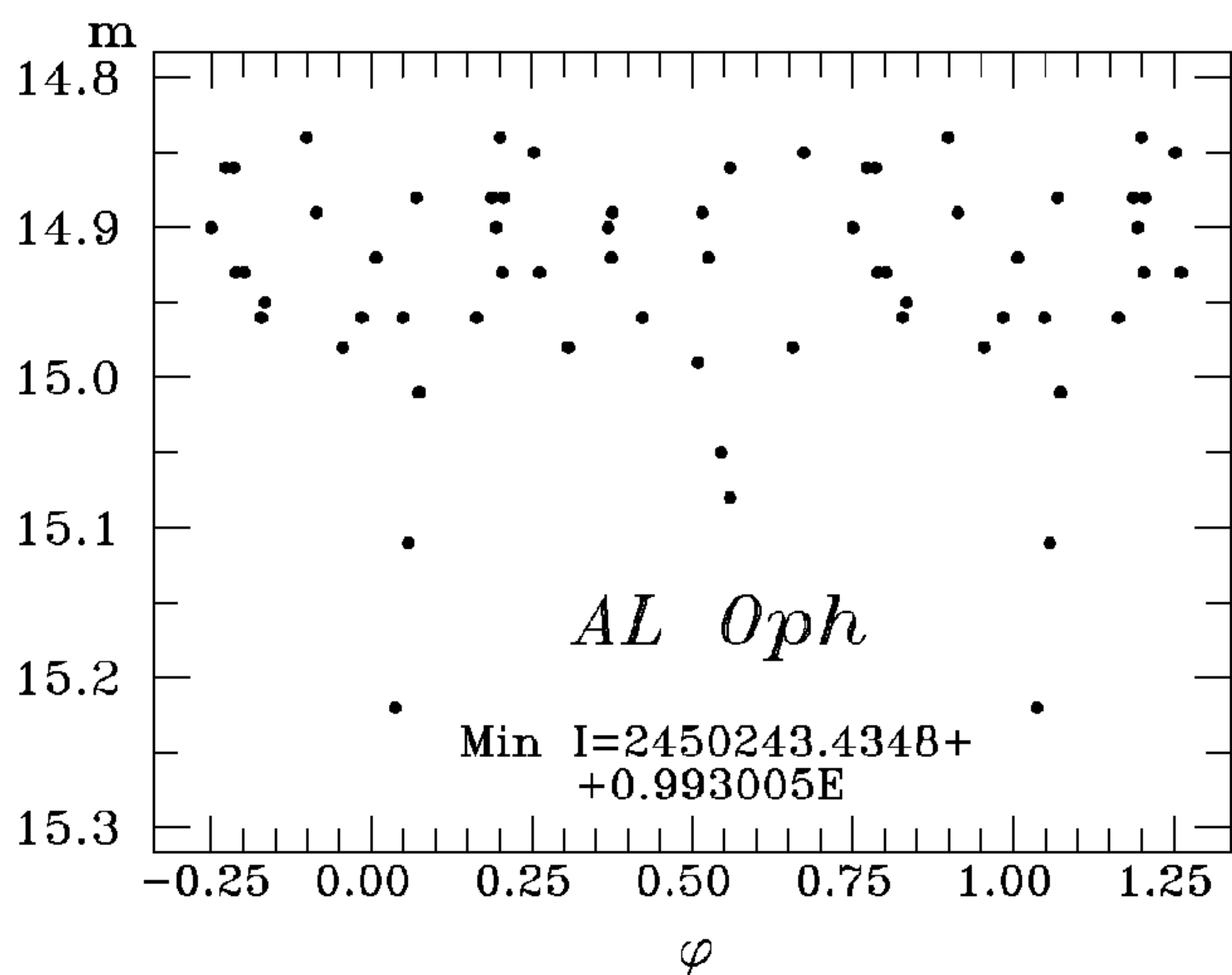


Figure 2. Phase light curve according to the elements by Šarounova and Wolf (1997).

used these elements to construct phase light curve by our observation (see Fig. 2.). There are 3 points corresponding to primary and 2 points corresponding to secondary minimum on it. Their moments and magnitudes are listed in Table 1.

Acknowledgement. The author is thankful to A.Paschke who initiated this work.

Reference

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ON THE MASS-RATIO OF THE ECLIPSING BINARIES OF W UMa TYPE

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ABSTRACT. The discrepancy between the photometric and spectroscopic mass-ratio in W UMa-type systems is examined by using all the available mass-ratio data derived by modern techniques from photoelectric and radial velocity curves. The new additional data confirm, with few exceptions, the dependence of the discrepancy on the spectral type, first established by Niarchos and Duerbeck (1991). It is suggested that this discrepancy may be due to the influence of a global circulation pattern on the measured radial velocities.

Key words: binaries: eclipsing, stars: mass-ratio, stars: W UMa systems

Introduction

The eclipsing variables of W UMa-type constitute a well-known subclass of close binaries named as late-type contact binaries. In spite of the great amount of theoretical work done so far, our theoretical understanding of the detailed phases of close binary evolutionary sequencing is rather poor and there are enormous obstacles in pursuing close binary evolution in a poorly theoretical approach. According to Leung (1988), a possible solution to this problem could be an observational approach, in which a variety of observed binary systems representing different phases of the evolutionary scheme, could be used to establish an observational evolutionary sequence, which could serve as the constraints for the theoretical model construction.

At present, there is considerable controversy

in the theoretical modeling of these systems, such as between the approaches of Lucy (1976), and Shu, Lubow and Anderson (1979). A precise determination of the physical parameters of W UMa stars is needed to check the models and to derive the evolutionary status for these stars.

Determination of the mass-ratio

During the last two decades two distinct developments had a great impact in deriving the basic astrophysical quantities describing the close binary systems. The first was the development of the Roche model for light curve analysis. The modern synthetic light curve codes, based on the Roche model, enable us to derive much more realistic and accurate physical parameters of close binary systems. Among those parameters the one of main interest is the mass-ratio of the system, which is necessary for the calculation of the absolute dimensions for single line spectroscopic binaries. For reasons discussed by Wilson (1978), only for W UMa systems with total eclipses the mass-ratio q_{ptm} can be determined with high accuracy by synthetic light curve techniques.

The second development is the cross-correlation method in deriving radial velocities for close binary systems. This technique has been successfully applied by several groups around the world (see for example Simkin 1974, McLean 1981a, 1983a, b, Hrivnak 1993). A method using broadening functions has also been applied by several investigators, e.g. Bra-

ult and White 1971, McLean 1981, Becker 1984, Rucinski 1992). By using modern digital reduction methods of radial velocity determinations, it was possible to achieve excellent results in securing accurate radial velocity curves for many close binary systems.

Nevertheless, our knowledge of the radial velocity curves of W UMa systems is still limited. Since the spectral lines are very broad and blended, and since the objects are usually too faint for obtaining good spectral resolution at sufficient time resolution with telescopes of the 2 meter class, spectroscopic studies of contact binaries lack precision.

Controversy on the mass-ratio

For an understanding of the evolutionary state of the W UMa systems, it is important to know the masses and the mass-ratio, if we hope to understand the evolutionary state of the W UMa systems. When the spectroscopic mass-ratio q_{sp} and the photometric one q_{ptm} differ, it is necessary to clarify the underlying cause. Discrepancies between q_{sp} and q_{ptm} have been noticed since the first determinations of photometric mass-ratios for contact binaries (Moch-nacki and Doughty 1972a,b, Wilson and Devinney 1973). It seems that such discrepancies exist for also other W UMa systems, in contrast of Leung's (1988) statement that photometric and spectroscopic mass-ratios agree, when the latter are based on modern methods of radial velocity curve determination. We notice that half of Leung's examples are systems with partial eclipses, where q_{ptm} is determined with no high accuracy (Wilson 1978).

It is generally recognized that the photometric mass-ratio can be determined with high accuracy for systems showing total eclipses (Wilson 1978). An attempt to reconcile q_{sp} and q_{ptm} by a proper simultaneous light and velocity solution has been made by Wilson (1979) and Van Hamme and Wilson (1985) in the case of AE Phe. Nevertheless, they obtained $q_{sp} \neq q_{ptm}$. It seems that the simultaneous solution does not really help in understanding the overall situation and very probably systematic effects

may seriously influence the results. The problem of compromise between q_{sp} and q_{ptm} remains. If such discrepancies are real, the spectroscopic mass-ratio q_{sp} is likely the quantity which suffers from unexplained systematic errors.

A possible solution

Despite the use of cross-correlation methods to obtain good spectroscopic orbits and mass-ratios, some systems yield noticeably differing q_s which cannot be explained by observational scatter. A hint towards the solution of the q -discrepancy was given by Niarchos and Duerbeck (1991). If the discrepancy is plotted as $\Delta q/q = 2(q_{sp} - q_{ptm})/(q_{sp} + q_{ptm})$ for systems with total eclipses as a function of spectral type, it is noted that q_{sp} is systematically larger than q_{ptm} for early spectral types (A, F), while it is smaller for types G and K.

The sample in Table 2 of Niarchos and Duerbeck (1991) was relatively small and the conclusion was not very convincing. We are able to enlarge our sample substantially so that we can reassess the validity of this discrepancy, and to test the Niarchos and Duerbeck (1991) hypothesis, whose main idea is as follows: in early type A systems, the smaller, cooler component 2 is irradiated by the hotter component 1, and the radial velocity amplitude K_2 is measured too small, resulting in $q_{meas} > q_{true}$. While, in late type W systems, the larger, cooler component 1 is irradiated and K_1 is measured too small, resulting in a $q_{meas} < q_{true}$.

In Table 1, some parameters for W UMa systems derived from light and radial velocity curves are listed. These data were taken from a recent work of Maceroni and Van't Veer (1996) and from Niarchos and Duerbeck (1991). The column "class" of Table 2 of Maceroni and Van't Veer (1996) should serve as a reference to judge the quality of the photometric solution and of the spectroscopic orbit. Only systems with four out of five classes of decreasing quality in radial velocity curve determinations and with three out of four classes of decreasing quality in light curve solutions were considered.

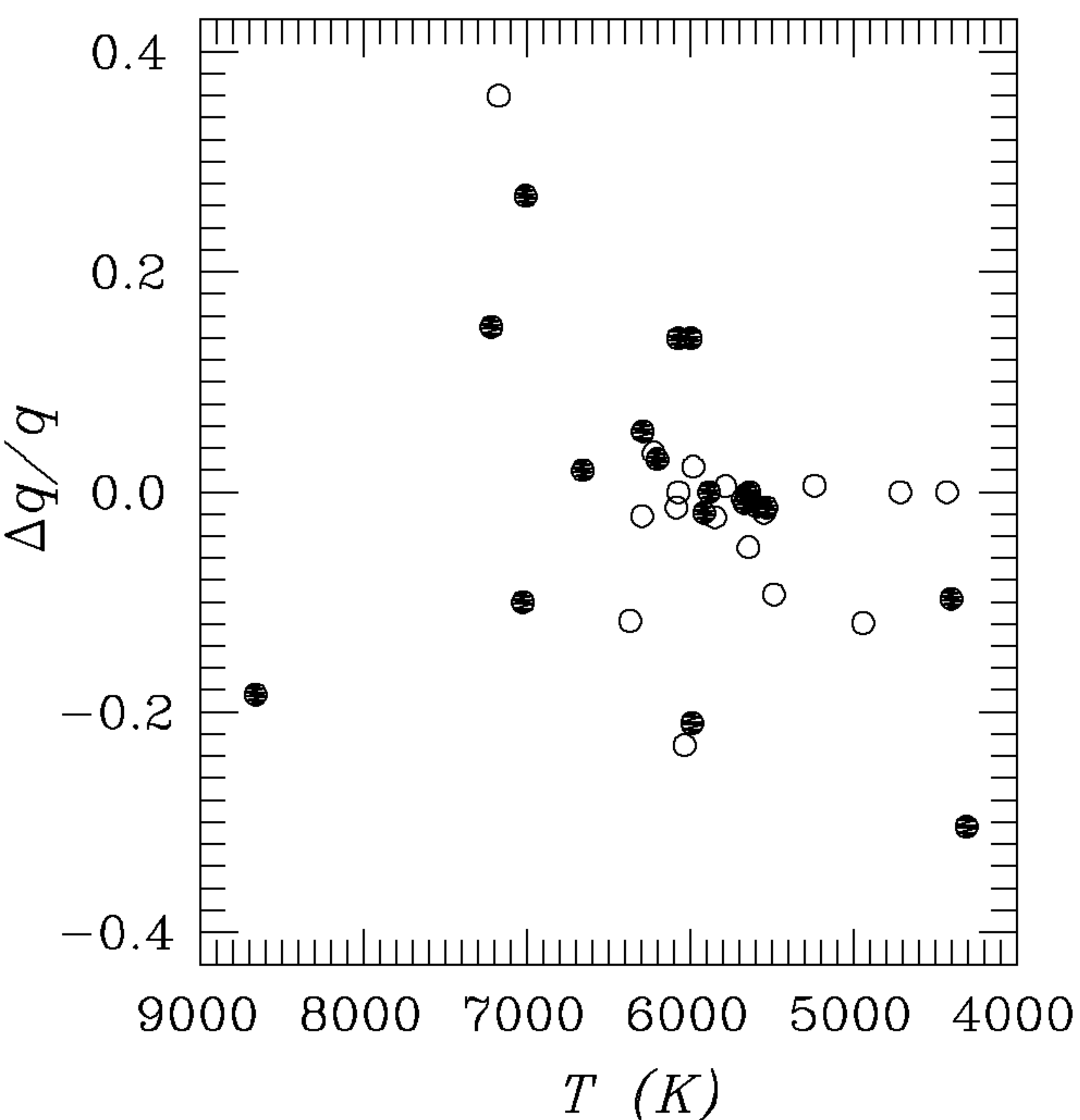


Figure 1: Discrepancy between spectroscopic and photometric mass-ratio of W UMa systems as a function of the mean temperature. Totally eclipsing systems are shown as filled circles, partially eclipsing ones as open circles.

Systems with total eclipses and modern methods of reduction are marked by an asterisk. T_{mean} is the mean temperature of the two components. The q -discrepancy for all systems listed in Table 1, defined in the same way as in Niarchos and Duerbeck (1991), is plotted in Fig. 1 as a function of the mean temperature. Totally eclipsing systems are shown as filled circles, partially eclipsing ones as open circles.

5. Conclusions

An inspection of Figure 1 reveals that the discrepancy between the photometric and spectroscopic mass-ratio changes as a function of the mean effective temperature (or the spectral type). The tendency is more clear for totally eclipsing systems. The most probable explanation of the dependence on the spectral type can be, according to Webbink (1977) and Kähler (1995), the large-scale streaming motions occurring between the luminosity-exchanging components, which distort the simple surface velocity field of two components in

bound rotation. It was found that the streaming motion is different for hot and cool systems and this may explain the dependence on the spectral type (Niarchos and Duerbeck 1991). These effects affect the radial velocities and the spectroscopic mass-ratio in a systematic way. By using a much larger sample of W UMa systems with accurate photometric and spectroscopic mass-ratios, it was shown, with a few exceptions, the validity of Niarchos and Duerbeck (1991) hypothesis about the discrepancy between the photometric and spectroscopic mass-ratio.

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Table 1. Parameters from light and radial velocity curves

n	Name	q_{ptm}	q_{sp}	T(mean) (K)	$\Delta q/q$	type	ref
1	CC Com*	0.518	0.470	4401	−0.097	W	2
2	V523 Cas*	0.571	0.420	4307	−0.304	W	1
3	RW Com	0.343	0.345	5239	+0.006	W	1
4	44i Boo	0.501	0.498	5677	−0.006	W	1
5	BX Peg*	0.371	0.372	5885	0.000	W	3
6	XY Leo	0.500	0.500	4713	0.000	W	1
7	BW Dra	0.280	0.280	6072	0.000	W	1
8	TY Boo	0.467	0.466	5652	−0.002	W	1
9	SW Lac	0.812	0.797	5549	−0.019	W	1
10	YY Eri	0.439	0.400	5487	−0.093	W	1
11	AB And*	0.491	0.491	5636	0.000	W	1
12	W UMa*	0.470	0.488	5997	+0.140	W	2
13	RZ Com*	0.436	0.430	5532	−0.014	W	1
14	BV Dra	0.411	0.402	6295	−0.022	W	1
15	AM Leo*	0.426	0.450	6290	+0.055	W	1
16	V752 Cen	0.300	0.311	6222	+0.036	W	1
17	U Peg	0.331	0.315	5642	−0.050	W	1
18	TX Cnc	0.596	0.530	6369	−0.117	W	1
19	SS Ari	0.302	0.295	5848	−0.023	W	1
20	AH Vir*	0.342	0.300	5592	−0.013	W	1
21	ER Ori	0.610	0.613	5785	+0.005	W	1
22	V502 Oph	0.377	0.370	6084	−0.014	W	1
23	AA UMa	0.551	0.564	5981	+0.023	W	1
24	AE Phe*	0.391	0.450	6073	+0.140	W	2
25	EZ Hya*	0.310	0.350	5988	−0.210	W	2
26	V508 Oph*	0.530	0.520	5915	−0.019	A	1
27	AU Ser	0.800	0.710	4940	−0.119	A	1
28	V566 Oph*	0.239	0.240	6659	+0.020	A	2
29	RZ Tau	0.372	0.540	7173	+0.360	A	2
30	AW UMa*	0.072	0.070	7025	−0.100	A	2
31	TV Mus	0.150	0.119	6034	−0.230	A	1
32	OO Aql*	0.843	0.835	5668	−0.010	A	1
33	AQ Tuc*	0.270	0.354	7007	+0.269	A	1
34	RR Cen*	0.180	0.210	7219	+0.150	A	2
35	V535 Ara*	0.361	0.300	8661	−0.184	A	1
36	VZ Psc	0.920	0.920	4426	0.000	A	1
37	Y Sex*	0.175	0.180	6200	+0.030	A	2

*systems with total eclipses

References:

1. Maceroni and Van't Veer (1996), 2. Niarchos and Duerbeck (1991), 3. Samec and Hube (1991)

POLYTHROPIC MODEL OF THE COMPONENT OF CLOSE BINARY SYSTEM

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ABSTRACT. In the present work we tried to resolve the problem about the detailed interior structure of the non-single star which is the component of close binary system. We have considered the case of self-gravitation potential of the gaseous sphere, which is influenced by the forces connected with rotation and tidal deformation from the companion.

Considered models appear to be remarkably centrally condensed when compared with corresponding models of the non-rotating single stars. This circumstance can lead to some evolutionary changes in the close binary systems, where one or two components

Key words: Stars: Binaries: Roche lobe, Inner Structure

Introduction

For a long time, so-called Roche lobe model was used for description of the centrally condensed synchronously rotating components of the close binary systems. Accordingly to such a model, each component is presented by the point mass surrounded by the diluted shell with negligibly small density. Within this model one can obtain an exact expression for surface levels of a binary star.

In the present work we tried to resolve the problem about the detailed interior structure of the non-single star which is the component of close binary system. For this aim we used self consistent field method (SCF), first employed by Ostriker et al., (1968) for investigation of the interior structure of the rotating stars (Ostriker and Mark, 1968).

The stellar structure depends upon various parameters. To simplify the problem, we adopted the following assumptions:

1) secondary component is a point mass ha-

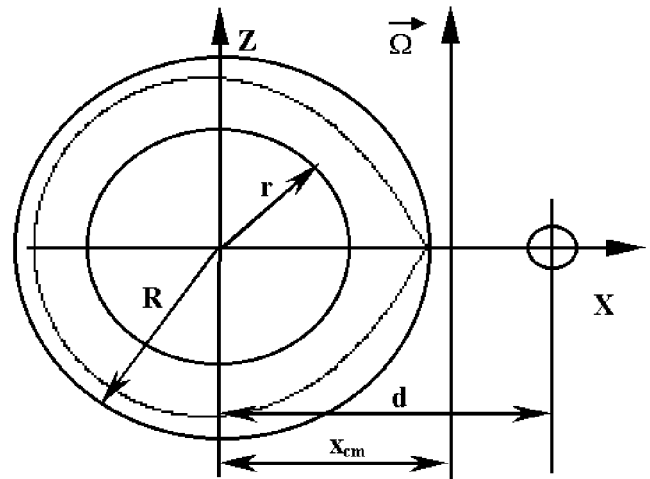


Figure 1: Graphical representation of the considered model

ving the corresponding gravitational potential;

2) angular rotational velocity of the primary equals to its orbital velocity (i.e., rotation and orbital movement are synchronous);

3) density distribution in primary is given by the barotropic equation;

4) the influence of magnetic fields and external forces is negligible.

Masses of primary and secondary components are M_1 and M_2 , the distance between the centres of mass of the components is d (fig.1), angular velocity of rotation is ω . The beginning of co-ordinate system is set in the centre of mass of primary component, x -axis is directed towards the centre of mass of the secondary and z -axis is parallel to $\vec{\Omega}$ vector (see Fig.1). We can write the system of equations:

$$\begin{aligned} \frac{1}{\rho} \nabla P &= \nabla (U_{self} + U_{rot} + U_{sd}) = \nabla B \\ \nabla^2 B &= -4\pi G \rho \\ P &= P(\rho) \end{aligned} \quad (1)$$

where U_{self} is potential of self-gravitation of primary, U_{rot} - centrifugal potential, U_{sd} - gravitation potential of the secondary component, B - total potential, the rest definitions have usual meaning.

In case the initial distribution of the density is set, then self-gravitational potential $U_{self}(r)$ will be the sum of two values: potential formed by the mass confined within the sphere of radius r and gravity potential of the mass which is situated between the surface of the considered sphere and outer boundary of the configuration.

$$U_{self} = -G \int_0^M |\vec{r} - \vec{r}'|^{-1} dm' - G \int_M^M |\vec{r} - \vec{r}'|^{-1} dm' \quad (2)$$

$$dm' = \rho dV' \quad (3)$$

where M_r -mass inside the sphere of radius r , dV -elementary volume.

Obviously, the first integral corresponds to the case when $r > r'$, and second one is valid for $r < r'$. Because of the solid-state character of rotation, the centrifugal potential has the following form:

$$U_{rot} = \frac{1}{2} \omega^2 ((x - x_{cm})^2 + y^2) \quad (4)$$

where x_{cm} - distance to the centre of mass of the system is given by:

$$x_{cm} = \frac{d \cdot M_2}{M_1 + M_2} \quad (5)$$

Gravitational potential of the second component is:

$$U_{sd} = -\frac{G \cdot M_2}{\sqrt{(d-x)^2 + y^2 + z^2}} \quad (6)$$

Having integrated the equilibrium equation

$$\frac{1}{\rho} \nabla P = \nabla B \quad (7)$$

we get:

$$H = B - B_s, \quad H = \int \frac{dP}{\rho} \quad (8)$$

where H -enthalpy; B_s - surface potential. In case the state equation is given, one can obtain the following relation:

$$\rho = \rho(H) \quad (9)$$

Relations (1)-(9) allow to calculate new density distribution. If calculated ρ_{new} differs from ρ_{old} greater than on certain value, then ρ_{new} is accepted as an initial approximation and next iteration is performed to get the self-consistence within the considered accuracy.

Computational scheme

It is reasonably to use undimensioned form of equations with the basis G, R, ρ_c , where R is a maximal radius of the star (beforehand fixed), ρ_c is a central density.

$$\begin{aligned} \rho' &= \frac{\rho}{\rho_c} \\ x &= \frac{r}{R} \\ U' &= \frac{U}{G \rho_c R^2} \end{aligned} \quad (10)$$

Let us divide the spherical volume with radius R onto spherical layers having the common centre and use $\rho_{nm}(x)$ - the coefficient of density decomposition on spherical functions upon sphere of radius x [6].

$$\begin{aligned} \rho_{nm}(x) &= \int_{-1}^1 P_m^n(\mu') d\mu' \int_0^{2\pi} \rho'(x, \mu' \phi') \times \\ &\quad \times \cos(m \cdot \phi') d\phi' \end{aligned} \quad (11)$$

Integrals can be easily calculated using Gauss formula (ω_i, ω_k -weights, μ_k, ϕ_i - gaussian abscissae, $\mu = \cos(\theta)$):

$$\begin{aligned} \rho_{nm}(x) &= \sum_{k=1}^N \omega_k P_m^n(\mu_k) \sum_{i=1}^N \omega_i \rho(x, \mu_k \phi_i) \times \\ &\quad \times \cos(m \cdot \phi_i) \end{aligned} \quad (12)$$

Then:

$$\rho_{nm}(x, \mu, \phi) = \rho_c \sum_{n=0}^N \sum_{m=0}^n \rho_{nm}(x) P_m^n(\mu) \times \cos(m \cdot \phi_i) \quad (13)$$

Now, let us consider the self-gravitation potential U_{self} . On the considered sphere it consists of two components: potential Q generated by the mass from this spherical volume and potential Φ of the mass outside this sphere: $U_{self} = Q + \Phi$. Using the well-known formulae of the celestial mechanics (Duboshin, 1968), one can get the total potential as a decomposition on the spherical functions:

$$Q(x, \mu, \phi) = \sum_{n=0}^N \sum_{m=0}^n Q_{nm}(x) x^{-n-1} P_m^n(\mu) \times \cos(m \cdot \phi_i) \quad (14)$$

$$\Phi(x, \mu, \phi) = \sum_{n=0}^N \sum_{m=0}^n \Phi_{nm}(x) x^{n+1} P_m^n(\mu) \times \cos(m \cdot \phi_i) \quad (15)$$

where $\Phi_{nm}(x)$, $Q_{nm}(x)$ are:

$$Q_{nm}(x) = C_{nm} \int_0^x x'^{n+2} \rho_{nm}(x') dx' \quad (16)$$

$$\Phi_{nm}(x) = C_{nm} \int_x^1 x'^{-n+1} \rho_{nm}(x') dx' \quad (17)$$

$$C_{nm} = \frac{2n+1}{2\pi\delta} \frac{(n-m)!}{(n+m)!}$$

$$\delta_m = 2 \quad m = 0$$

$$\delta_m = 1 \quad m = 1, 2, 3, \dots$$

Finally:

$$U_{self}(x, \mu, \phi) = \sum_{n=0}^N \sum_{m=0}^n U_{nm}(x) P_m^n(\mu) \times \cos(m \cdot \phi_i) \quad (18)$$

$$U_{nm}(x) = \Phi_{nm}(x) x^n + Q_{nm}(x) x^{-n-1} \quad (19)$$

Calculation of the indefinite integrals (16), (17) is similar to that of the indefinite integral of the function which is tabulated. Given decompositions do not contain the sinusoidal members, under the considered co-ordinate system they appear to be zero. On each sphere with radius x , the density and potential are described as a triangle matrix:

$$\begin{vmatrix} A_{00} & 0 & 0 & 0 \\ 0 & A_{11} & 0 & 0 \\ A_{20} & 0 & A_{22} & 0 \\ 0 & A_{31} & 0 & A_{33} \end{vmatrix}$$

On the next step we should calculate the enthalpy (in the same units as potentials):

$$H = U_{self} + U_{sd} + U_{rot} - B_s \quad (20)$$

Constant B_s from (8), (20) is determined as maximum of value B for $\mu = 0$, $\phi = 0$, $x = 1$ that corresponds to the directions towards the secondary component. Simultaneously, we keep the condition that new configuration should be situated inside the sphere $x = 1$. Stellar surface is determined by the condition $H = 0$. If we select

$$P = K \rho^{\frac{1}{n}+1} \quad (21)$$

as a state equation, then enthalpy and density will be connected as following:

$$\rho = \left(\frac{G \rho_c R^2 H}{K(n+1)} \right)^n \quad (22)$$

where n is a polytropic index.

Let us express K through the central density and central value of the enthalpy H_c and mass through the undimensioned mass

$$K = \frac{G R^2 H_c}{\rho_c^{\frac{1}{n}+1} (n+1)} \quad (23)$$

$$M = \rho_c R^3 H_c^{-n} \quad (24)$$

Undimensioned mass is:

$$M' = \int_0^1 \int_{-1}^1 \int_0^{2\pi} H^n x^2 dx d\mu d\phi \quad (25)$$

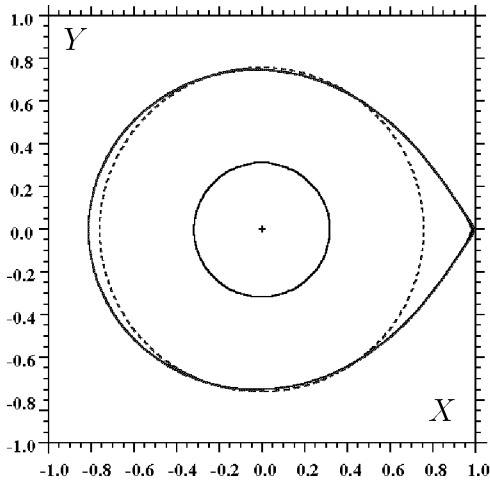


Figure 2: Equipotential surfaces. The inner one corresponds to decreasing of the potential e times with respect to its central value. $M_1/(M_1 + M_2) = 0.5$ $n = 3$

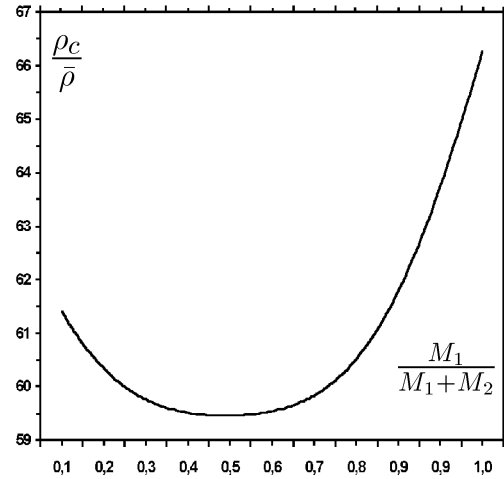


Figure 4: The dependence of ρ_c/ρ ratio upon mass ratio

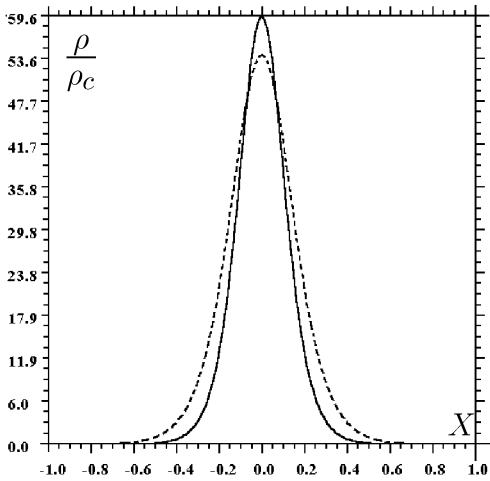


Figure 3: The density profile. $M_1/(M_1 + M_2) = 0.5$ $n = 3$. Dashed curve - single star, solid curve - component of double system.

Let us define the undimensioned function f_h . It is Lane-Emden function in the scale where the undimensioned radius of the configuration is $R = 1$. Therefore, the undimensioned function f_h can be used in searching for dimensioned physical values:

$$f_h(x) = \frac{H(x)}{H_c} \quad (26)$$

The values sought for (density, pressure, etc) can be expressed using f_h function:

$$M' = \int_0^1 \int_{-1}^1 \int_0^{2\pi} f_h^n x^2 dx d\mu d\phi \quad (27)$$

$$\rho = \rho_c f_h^n \quad (28)$$

$$P = P_c f_h^{n+1} \quad (29)$$

$$K = \frac{G\rho_c}{n+1} R^{\frac{3}{2}+2} \left(\frac{M'}{M} \right)^n \quad (30)$$

Conclusion

We have investigated the problem about the interior structure of the self-gravitating gaseous sphere, which is influenced by the forces connected with rotation and tidal deformation. Obtained solution generally depends upon mass ratio $M_1/(M_1 + M_2)$ and polytrope index n . It is clear, that Roche model for homogeneous incompressible ellipsoid and that for the point mass are the asymptotic solutions of the present problem ($n=0$ and $n=3$ respectively). Therefore, the configuration of the level surfaces for $n=0$ should well fit to the level surfaces of homogeneous ellipsoid and for $n = \infty$ to the level surfaces of point mass.

One of the most important results of the present study consists in the following. As one can see from fig.3, considered models are remarkably centrally condensed when compared with corresponding models of the non-rotating single stars. This circumstance can lead to some evolutionary changes in the close binary sy-

stem, where one or two components fill in their Roche lobes e.g., systems of W UMa).

Such stars can have shorter life-time depending upon the degree of additional central condensation and size of the volume inside the stellar core where it takes place. Taking into account that the rate of energy production in pp or CNO cycle is proportional to ρ_c^2 and T_c^n (where n varies from 4 to 20), one can conclude that even modest additional condensation of core gas can accelerate the rate of stellar evolution.

Acknowledgements. The author is thankful to I.L.Andronov and S.M.Andrievskij for helpful discussions.

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TIME-RESOLVED OPTICAL SPECTROSCOPY AND PHOTOMETRY OF THE PECULIAR POLAR BY CAM(=H0538+608)

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ABSTRACT. Results of simultaneous spectral and photometric observations of the peculiar polar BY Cam in the high state of brightness ($V = 14^m.2 - 15^m.6$) obtained in February 1990 and March 1991 at the 6-m telescope of SAO RAS are presented.

Key words: Stars: Cataclysmic Variables; individual: BY Cam

Variations (from night to night, during an orbital period and a shorter timescale variability of 3–5 min) of the equivalent widths ($W\lambda$), the relative intensities (R_c), the radial velocities (V_r) and the halfwidths (FWHM) of the Balmer ($H\beta$, $H\gamma$, $H\delta$) and the Helium (HeII 4686 Å) emission lines and the light curves in the B filter have been investigated.

The equivalent widths and relative intensities of emission lines have revealed a maximum in a phase range of the orbital period 0.3–0.5 (the ephemeris by Mason et al., 1989). The equivalent width of the HeII 4686 emission line was significantly less during all phases of the orbital period in a pulsing state (on March 10) in comparison with a flaring state (on February 25 and March 12) observed in the simultaneous light curves. Halfwidths (FWHM) of the Balmer emission lines in the pulsing state showed a 4-fold increase over the orbital period which was not seen in the flaring state.

The behaviour of the halfwidths of the Balmer and the HeII 4686 lines is strongly diffe-

rent, which is evidence of a geometric separation of the line radiation regions in the system.

Quasi-periodic oscillations (QPO) were detected in the Johnson-B light curves on all dates of our observations. Power spectra of light curves on March 10, 1991 in the pulsing state showed significant QPOs with a period of 3 min. The 30-minutes quasi-periodic oscillations were seen in the flaring state on March 12, 1991 in an orbital phase range 0.7–1.1.

The radial velocity curves based on the measurements of centres of gravity of the emission lines corresponding to the broad components of the lines could not be always approximated by sinusoids. The amplitudes of the radial velocity curves in the pulsing state showed deviations up to 1.6 times on a time scale of 0.1–0.2 of the orbital period (20–40 min) which indicate the fast changes in the accretion geometry. A comparison of the radial velocity measurements of different authors by the phase diagramm method showed a significant temperature-geometric asymmetry of the accretion structure probably caused by the two-pole accretion in the system. Possible reasons for the spectral and photometric variations are discussed.

To appear in the Bulletin of the Special Astrophysical Observatory, v 45.

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DETECTION OF SUPERHUMPS IN THE DWARF NOVA PV PERSEI

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ABSTRACT. The CBA (Center for Backyard Astrophysics) Belgium Observatory belongs to a global network of small photometric telescopes, that study periodic phenomena in Cataclysmic Variables (CVs). This network is among the leading examples of successful partnerships between professional and amateur astronomers. In a few occasions, CBA stations operate on a stand-alone basis on some selected CVs. This paper reports the results of such an individual photometry campaign. The dwarf nova PV Per was observed for three nights during its outburst in September 1996 at the CBA Belgium Observatory. Unfiltered differential CCD photometry revealed superhumps with a period of 0.0805 ± 0.0001 days. This finding establishes PV Per as being a new member of the SU UMa-type dwarf novae.

Key words: Stars: cataclysmic: PV Per

comprise SU UMa-type dwarf novae, intermediate polars (and DQ Her stars), permanent superhumpers (e.g., nova-like objects) and helium CVs, for which long, dense time-series differential photometry is performed.

Mentor of the CBA network is Columbia University astronomer Joe Patterson, who directs the collaboration and analyses the photometric CCD data. Participating observing stations are located in 6 continents and most are operated by dedicated amateur astronomers. The majority of the CBA "backyard" observatories allow robotic observations, meaning that all night long autonomous operation is guaranteed.

Target campaigns and results of the CBA are regularly reviewed on the CBA Web site (<http://www.cba.http://www.astro.columbia.edu/>).

1. Introduction

The Center for Backyard Astrophysics (CBA) is a multi-longitude network of small photometric telescopes, owned by talented amateurs, who study periodic phenomena in Cataclysmic Variables (CVs). It is among the leading examples of successful partnerships between professional and amateur enthusiasts, producing vast amounts of high-quality variable star data.

Since 1991, the CBA network has been engaged in long-term photometric studies of CVs, primarily focusing on binary orbital periods, rotational periods, superhump periods and accretion disk precession periods. Target objects

2. The CBA Belgium Observatory

The CBA Belgium Observatory is located in Flanders, Belgium. The observatory building is a slide off roof structure, measuring 3m by 4m. Its primary instrument for CCD photometry is a computer controlled 25-cm f/6.3 Meade Schmidt-Cassegrain telescope on a permanent tripod. It is equipped with a SBIG ST-7 CCD camera (Kodak KAF-0400 CCD for imaging and Texas Instruments TC211 CCD for guiding) providing a field of view of approximately 15×10 arcminutes.

The observatory furthermore houses a laptop computer (Pentium P100), which controls all telescope and CCD operations:

- camera control and unfiltered photometric imaging are done using the CCDOPS software of SBIG. Images are stored as FITS files.
- telescope guiding is realised through a special software package, called "Star Track", written by the author. It updates the telescope position on a regular basis to keep it aligned on a reference star, and it continuously monitors sky conditions.

The described set-up allows all-night long autonomous and unattended operation. The only human interaction required is for opening and closing of the observatory, and initialisation of the telescope, camera and computers. This process takes between 10 and 15 minutes.

After an observing night, data reduction is done on a dedicated PC (Pentium P133), employing a commercial package for differential PSF (Point Spread Function) photometry. The final data analysis uses some special software written by the Belgian amateur astronomer Patrick Wils, who implemented routines for PDM (Phase Dispersion Minimization), a period determination technique developed by R.F. Stellingwerf (Stellingwerf, 1978).

3. Observations of PV Per during the September 1996 outburst

Although the CBA observatories primarily participate in multi-longitudinal coordinated campaigns on selected cataclysmic variables, individual initiatives are encouraged, especially if the latter deal with searching for superhumps in rarely outbursting dwarf novae. We report the results of such a successful individual campaign.

PV Persei is an UG (U Geminorum) type dwarf nova with a photographic magnitude range from mag 14.9 to mag 20:. It is located at R.A. = $02^h42^m53.57^s$, Decl. = $+38^\circ04'02.6''$ (J2000.0).

An archive study of the Sonneberg plate collection revealed that PV Per had rather frequent outbursts (Busch and Haeussler, 1979). A detailed analysis of these outburst data already

indicated the existence of both short, faint outbursts and long, bright outbursts. The latter showed an initial slow decline, followed by a 1 mag d-1 brightness drop, suggesting the possible SU UMa-type nature of this object.

The first positive detection of PV Per during its September 1996 outburst was visually made by amateur astronomer Eric Broens, Belgium on 1996 September 15.924 UT (Vanmunster, 1996). Since the object was part of an alert programme on little studied cataclysmic variables (Vanmunster, 1997), set up by the Variable Star Section of the Belgian Astronomical Association, other amateurs were immediately notified of the ongoing outburst, through the Cataclysmic Variables Circulars. These electronic circulars are distributed to over 30 amateur and professional astronomers all over the world.

The CBA Belgium observatory was the first to confirm the ongoing outburst and instantaneously started unfiltered differential CCD photometry, which was again repeated on the following two nights. The resulting light curve is shown in figure 1.

Observations were carried out with the equipment described above. We used 2×2 on-chip summation, with exposure times of 180 sec and a dead-time of 10 sec throughout the observations. All frames were corrected for standard debiasing and flat-fielding. The differential magnitudes were derived using a primary comparison star (GSC 2845 1482, mag 12.3) located approximately $1.1'$ SE of the variable.

At the time of our first run on September 15, 1996, superhumps had already clearly developed (see figure 1), with a semi-amplitude of 0.18 magnitude. This finding established PV Per as a new member of the SU UMa-type dwarf novae. The humps showed a steep rise and gradual decline, which is characteristic for SU UMa-type dwarf novae early in their development of superhumps.

We made 196 photometric observations at CBA Belgium Observatory, between September 15-17, 1996. After heliocentric correction and after subtracting a linear trend of decline, we used the Phase Dispersion Minimization

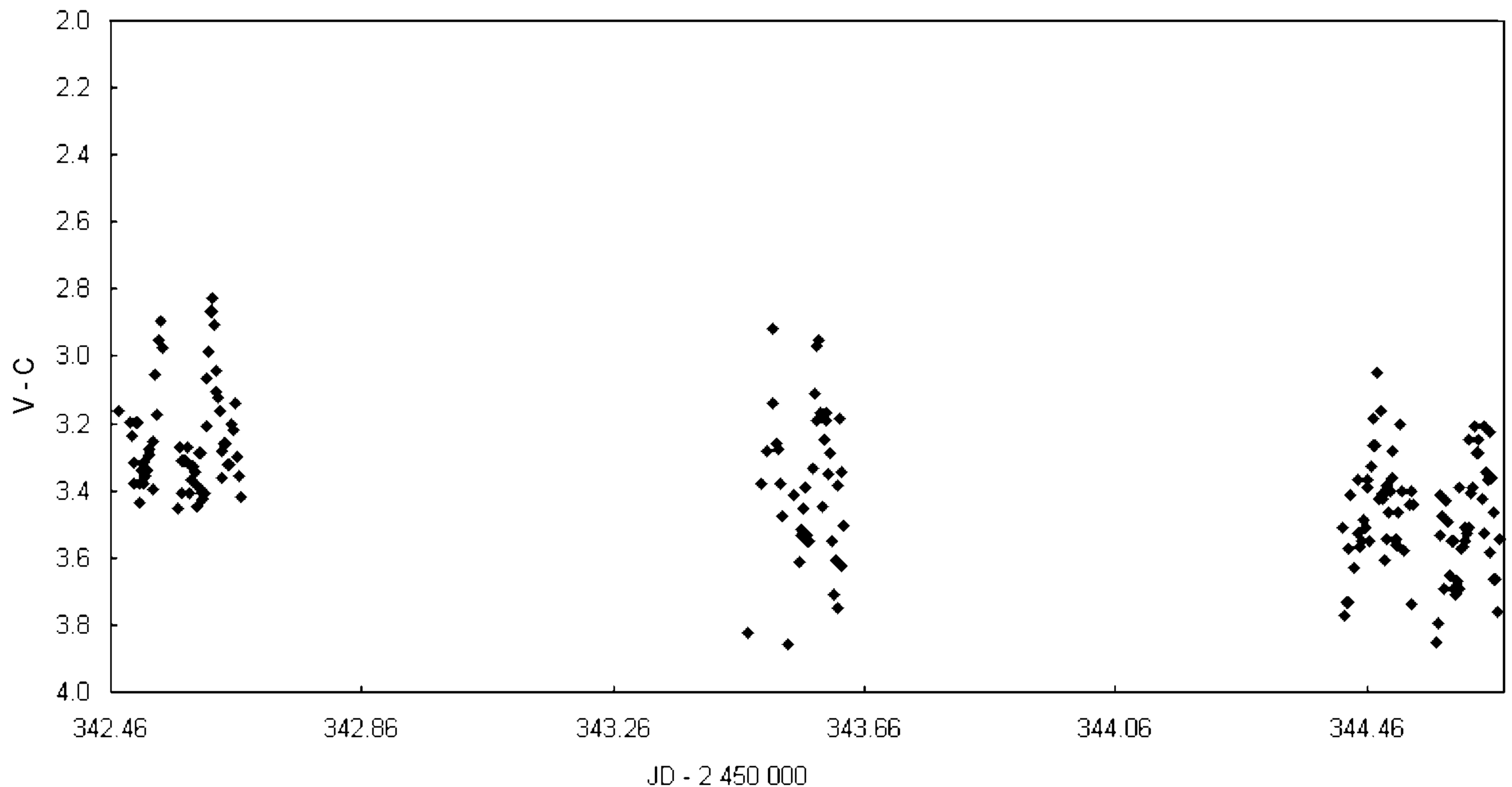


Figure 1. Overall unfiltered light curve of PV Per during the September 1996 outburst. V-C is the difference between PV Per and the comparison star. The primary features in the light curve are the superhumps.

(PDM) method to derive a superhump period of $0.0805 (\pm 0.0001)$ day.

Our superhump observations and superhump period value were confirmed by Taichi Kato and his team, observing at Ouda Observatory, Kyoto University, Japan during the nights of September 16-18, 1996. He derived a superhump period of 0.0804 day (Kato, 1996).

Further observations to determine more precise outburst characteristics and the supercycle length are highly desirable.

Acknowledgment. The author is grateful to E. Broens for promptly notifying the variable star community of the PV Per outburst, to Taichi

Kato and his team for confirming the superhump detection and to the Center for Backyard Astrophysics for their continuous support in our stellar CCD photometry research work.

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THE LOW DISPERSION SYNTHETIC SPECTRA OF COOL GIANT STARS

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ABSTRACT. The mean energy distribution of cool giant stars was used for comparison with synthetic spectra. The synthetic spectra was calculated using the various grids of stellar model atmospheres.

Key words: Cool giant stars, spectrophotometry, synthetic spectra, parameters

In recent years a large effort has been made to compute parameters of the bound-bound transitions for atoms, ions and molecules. The little attention has been given to the free-free and bound-free transitions of diatomic molecules and their ions, which can have a significant contribution in continuous opacity. Moreover the unknown sources of opacity in atmospheres of cool giant stars have been supposed because the discrepancies between synthetic and observed spectra in region wavelength with $\lambda < 450\text{nm}$ have been found (Komarov & Dulapchi, 1993, Dragunova & Belik, 1996).

To study this effect the synthetic spectra were calculated with interval 0.01 nm and with parameters - T_{eff} (effective temperature) from 4000 to 6000K, $\log g$ (gravity) for 2.0, 2.5 and 3.0, $[\text{Fe}/\text{H}]$ (metallicity - abundance of elements of group Fe in the atmosphere of star with respect to solar one) for 0.0, -0.5 and -1.0. The models were calculated for interpolated fundamental parameters (Tsymbal, 1996) and than the synthetic spectrum were averaged for interval 5 nm. The synthetic spectra of giant stars of later spectral types were not calculated because this calculation needs to take into account the molecular opacity. The new list of lines was used in the wavelength range of $\lambda\lambda$ 320-900 nm (Kurucz, 1993b).

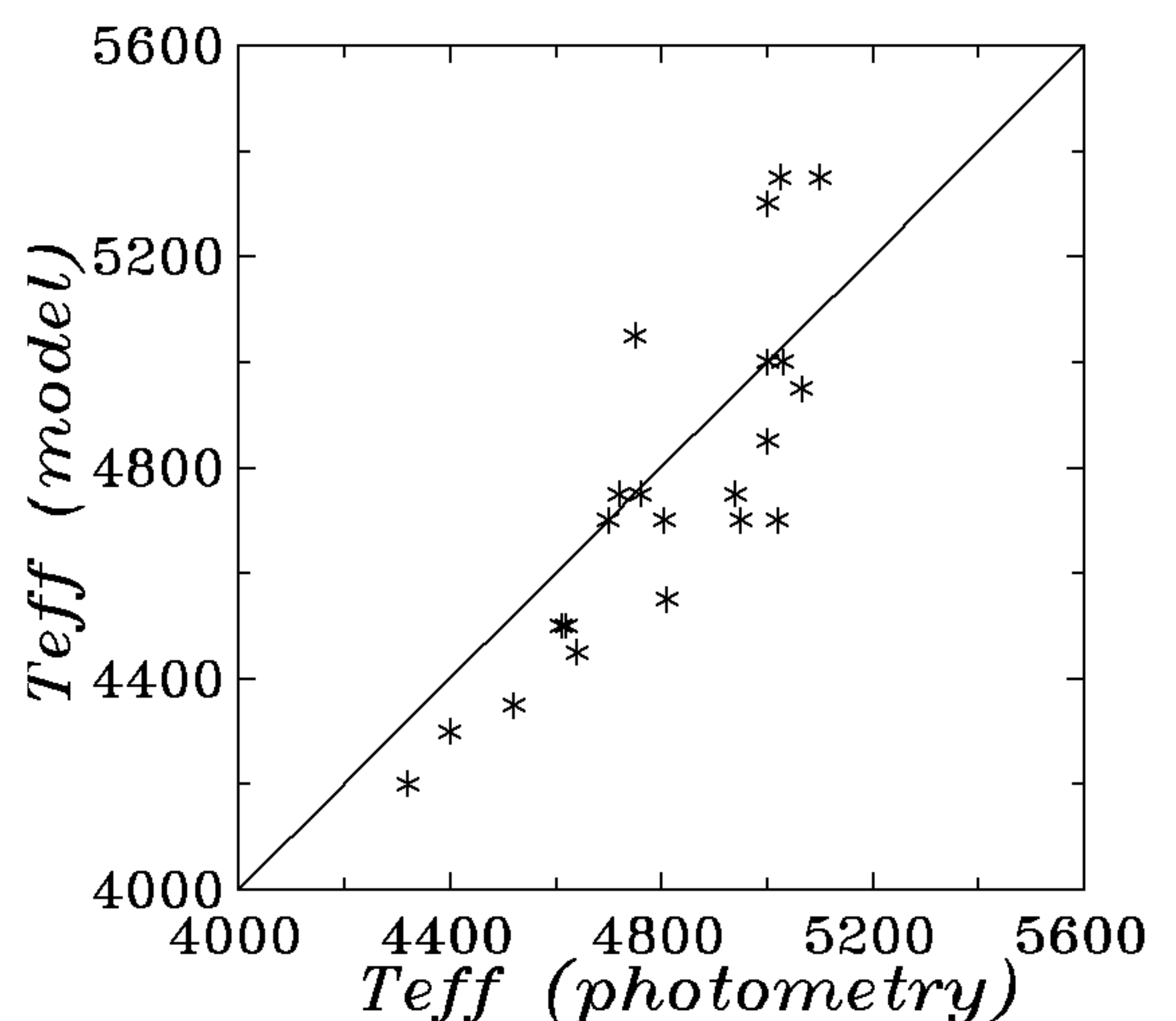


Figure 1. The comparison of temperatures.

In our paper the preliminary results of the calculations of synthetic spectra using the different grids of models of atmospheres (Bell et al., 1976, Kurucz, 1979, Kurucz, 1988, Kurucz, 1993a) and their comparison with observed spectra (Dragunova et al., 1997) are presented. The comparison was made in the following way:

- the calculated synthetic spectrum was interpolated for interval temperatures 50K ;
- the point nearly "continuum" was selected (maximum flux);
- the seven points was used to study the coincidence of synthetic and observed spectrum ;
- the minimal differences was found for selected grid of values T_{eff} , $\log g$ and $[\text{Fe}/\text{H}]$.

The obtained parameters of the cool giants atmospheres are given in the Table 1.

The parameters of several cool stars are obtained too and are given in the Table 2. The Figure 1 is presenting the comparison of

Table 1. The parameters of stellar atmospheres.

Sp	T _{eff}	lg g	[Fe/H]
G0III	5550	2.5	-1
G8III	5050	2.5	-1
G9III	5150	2.5	-1
K0III	4900	2.5	-1
K1III	4700	2.5	-1
K2III	4650	2.5	-1
K3III	4350	2.5	-1

T_{eff} calculated using the grid of models (Kurucz, 1993a) and T_{eff} recieved by means of the photometry for 22 stars.

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Table 2. The parameters of stars.

BS	Sp	T _{eff}	lg g	[Fe/H]
6132	G8III	4950	2.5	-1
265	G8III-IV	4550	3.0	-1
271	G8III-IV	5000	2.5	-1
4100	G8III-IV	4700	2.5	-1
5787	G8III-IV	4700	3.0	-1
7478	G8III-IV	4850	2.5	-1
4471	G9III	5000	2.5	-0.5
4932	G9III	5350	2.5	-0.5
7754	G9III	5300	2.5	-1
188	K0III	4850	2.5	-1
2990	K0III	5150	2.5	-1
3547	K0III	5050	2.5	-0.5
4057	K0III	4350	2.5	-1
4301	K0III	4700	2.5	-1
6698	K0III	4750	2.5	-1
7949	K0III	5050	2.5	-1
5025	K1III	5350	3.0	-1
6695	K1III	4850	2.5	-1
7150	K1III	4450	2.5	-0.5
7193	K1III	4900	2.5	-1
7324	K1III	4500	3.0	-0.5
8173	K1III	4750	2.5	-1
8694	K1III	5050	2.5	-1
74	K2III	4650	2.5	-1
334	K2III	4750	2.5	-1
603	K2III	4300	2.5	-1
617	K2III	4500	2.5	-0.5
1481	K2III	4700	2.5	-1
5340	K2III	4200	2.5	-1
5854	K2III	4850	2.5	-1
6603	K2III	4550	2.5	-1
6913	K2III	4800	2.5	-1
165	K3III	4450	2.5	-1
464	K3III	4350	2.5	-1
3748	K3III	4200	2.5	-1
3845	K3III	4150	2.5	-1
5429	K3III	4300	2.5	-1
5947	K3III	4300	2.5	-1
6973	K3III	4450	2.5	-1

THE MEAN STELLAR SPECTRA OF COOL GIANT STARS

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ABSTRACT. The mean values of energy distributions in spectra of cool stars of various spectral types have been found using the Catalogue of spectra of 555 stars.

Key words: Cool giant stars, evolution of stars

The mean distributions in radiation spectra of cool giant stars in wide range of wavelengths are necessary for investigation of short- and long-time variations of various spectral features, determination of mean characteristics of stars, the determination of continuum placement in spectra of quiet cool stars and so on. Approximately 30 years ago the observations of spectra in near IR-region of stars of various spectral types using the methods of absolute-relative spectrophotometry were begun at Odessa Astronomical Observatory following prof. V.P. Tsessevich's example.

The new catalogue (Komarov et al.) of energy distributions in spectra of 555 stars have been used to receive the mean distributions of energy in spectra stars. Here we present only the data for cool giant stars which have been used for comparison of theoretical (synthetic) and observed stellar spectra (Belik et al.). These distributions are given on Figures 1-6 with list of BS-numbers of stars which were averaged.

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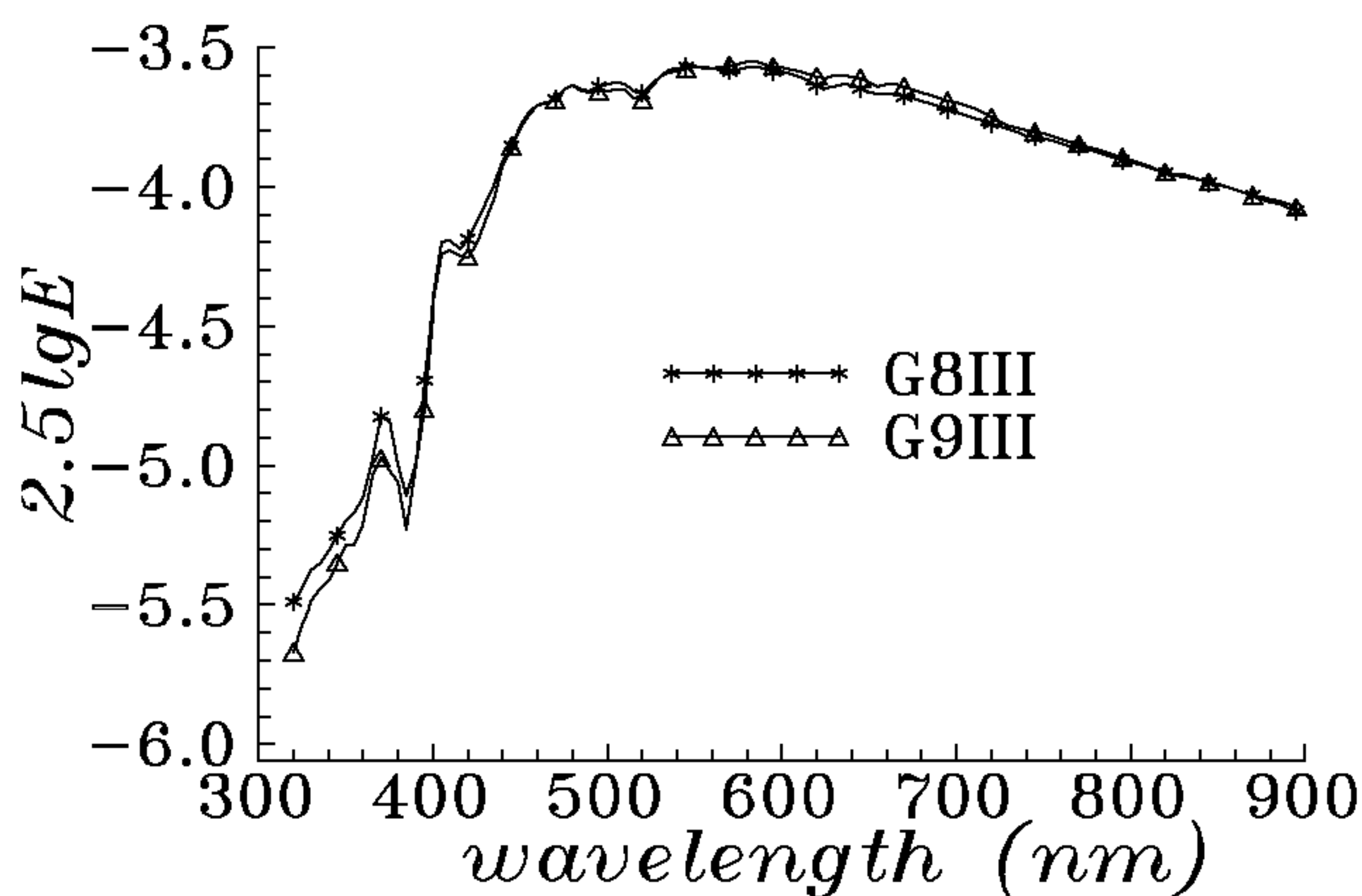


Figure 1. G8III: BS 2985, 5602, 5681, 6075, 6132, 6148; G9III: BS 4471, 4932, 7310, 7754, 8538.

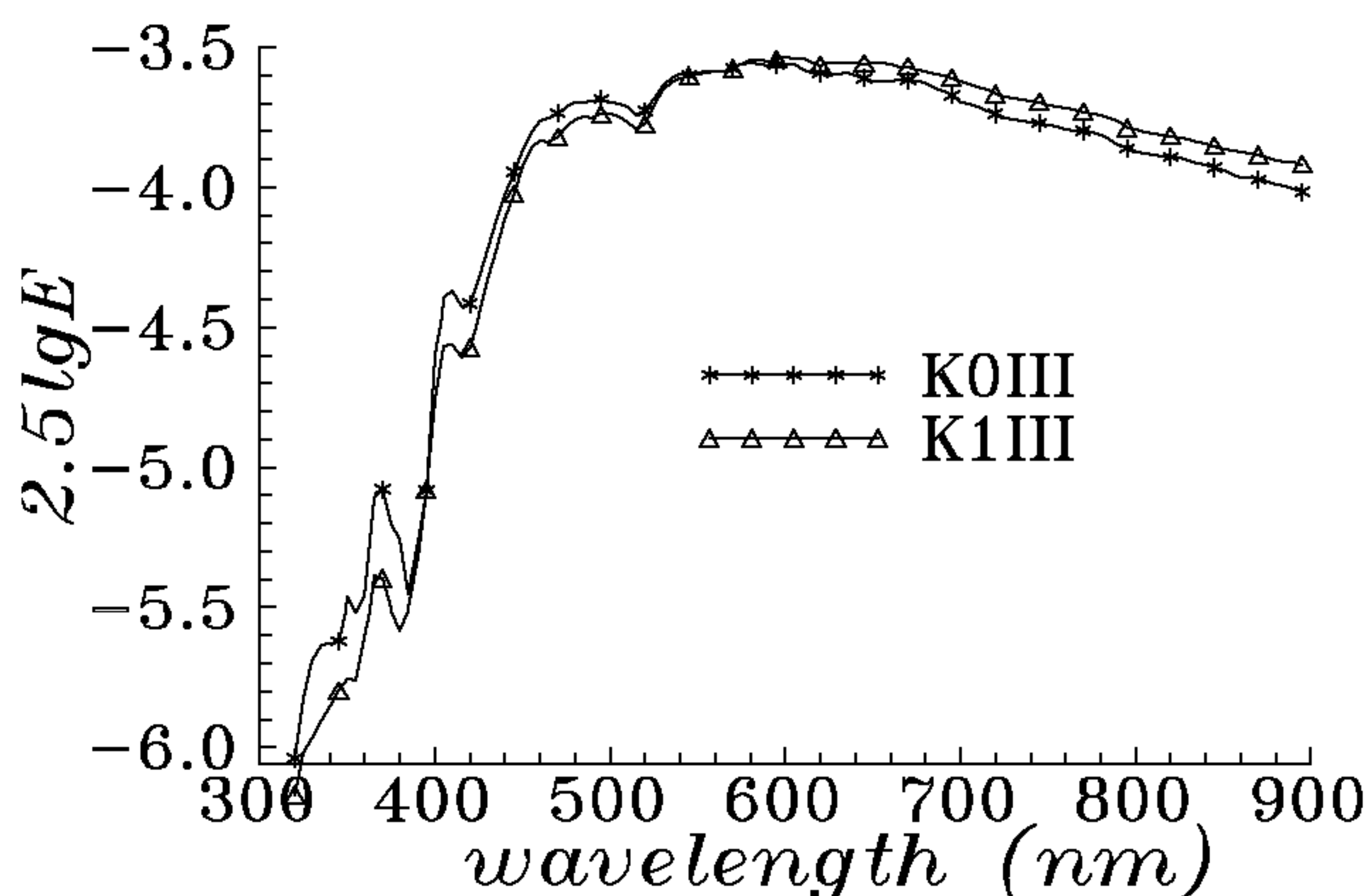


Figure 2. K0III: BS 188, 2990, 3547, 4301, 6698, 7949; K1III: BS 7150, 7193, 7234, 8173, 8694.

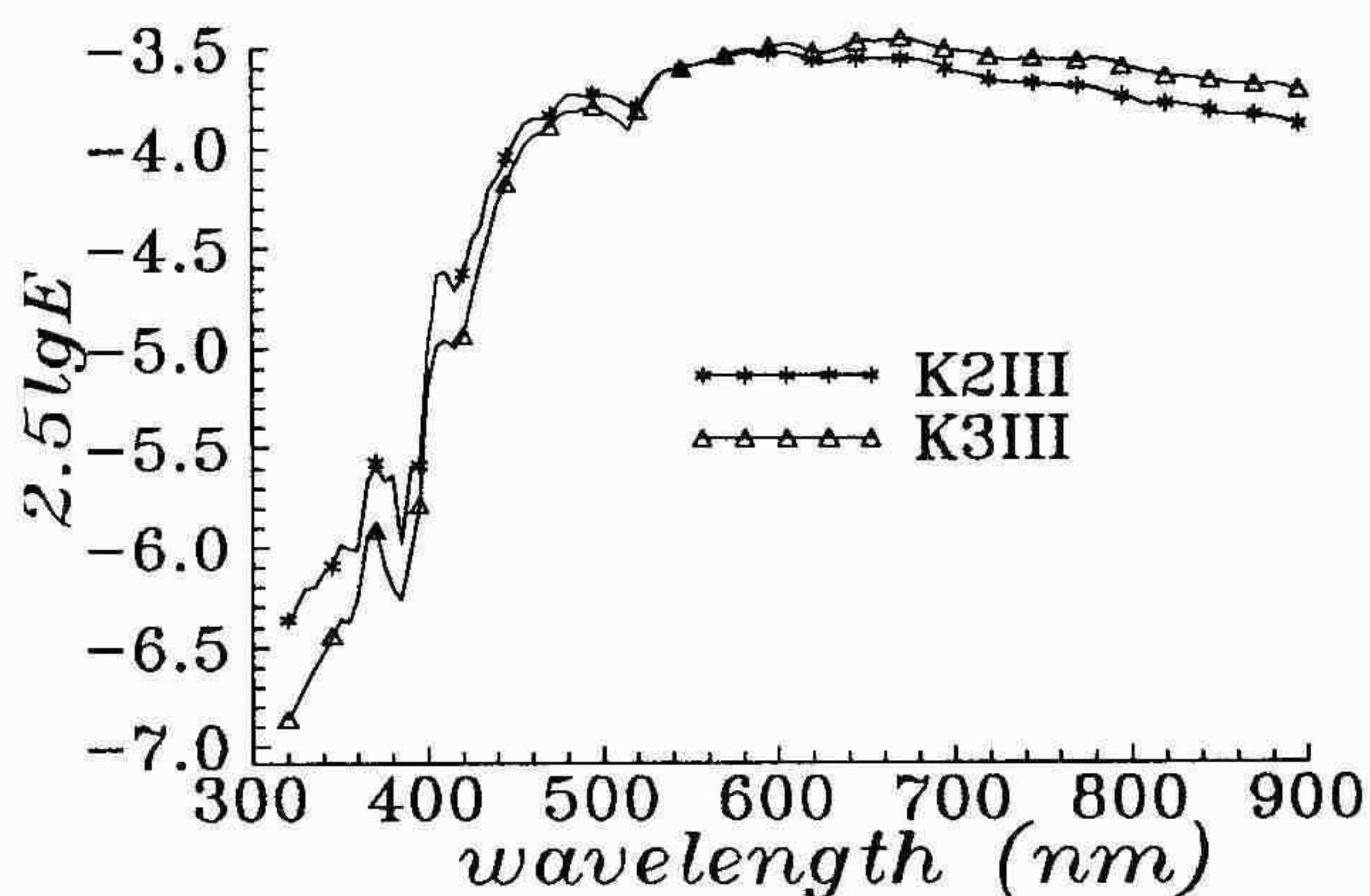


Figure 3. K2III: BS 74, 334, 617, 5854, 6603; K3III: BS 165, 464, 3845, 5429, 6973.

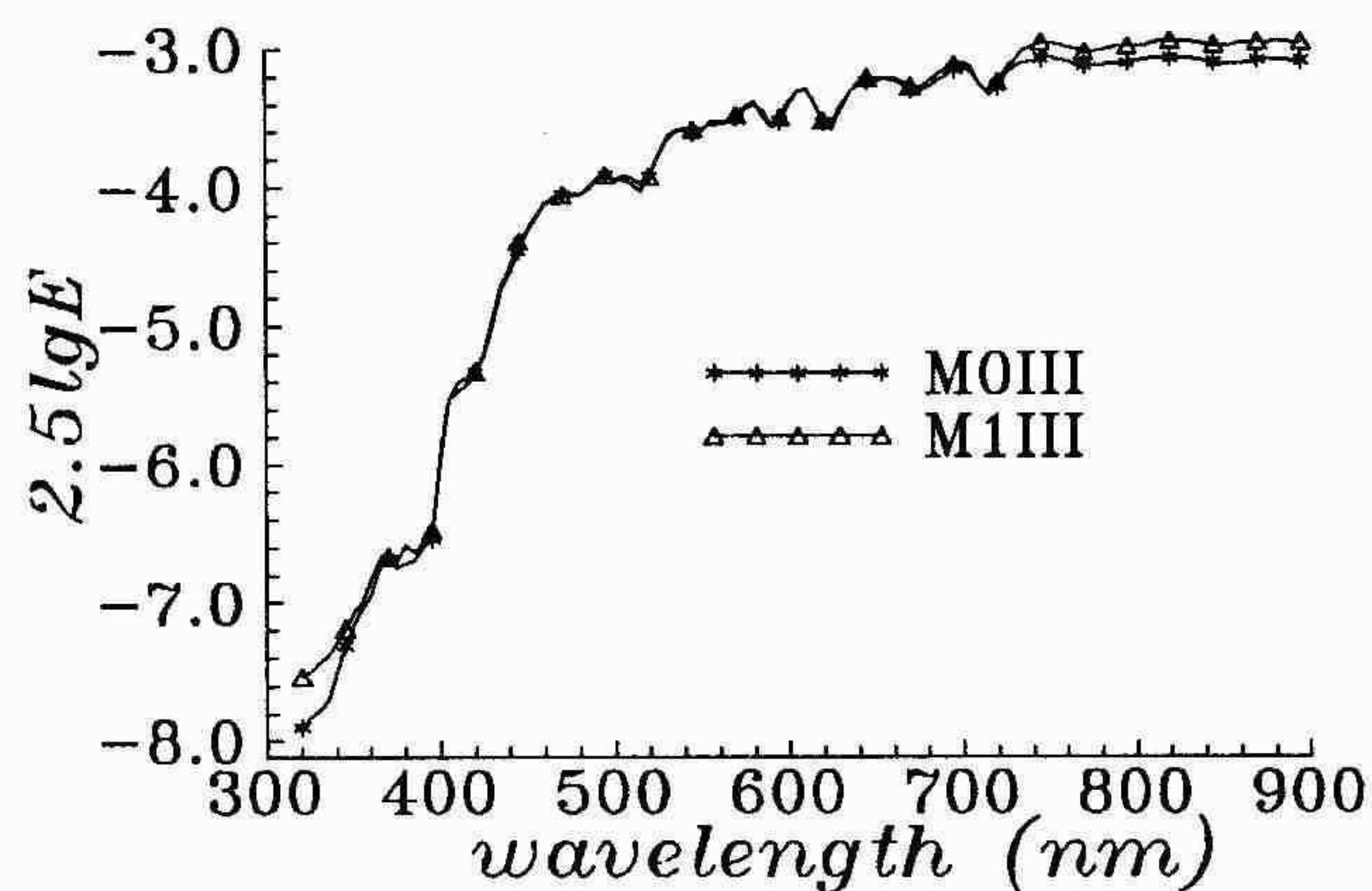


Figure 5. M0III: BS 1231, 2905, 3705, 4069, 4434, 7405; M1III: BS 585, 2011, 4517, 6056, 8225, 8284.

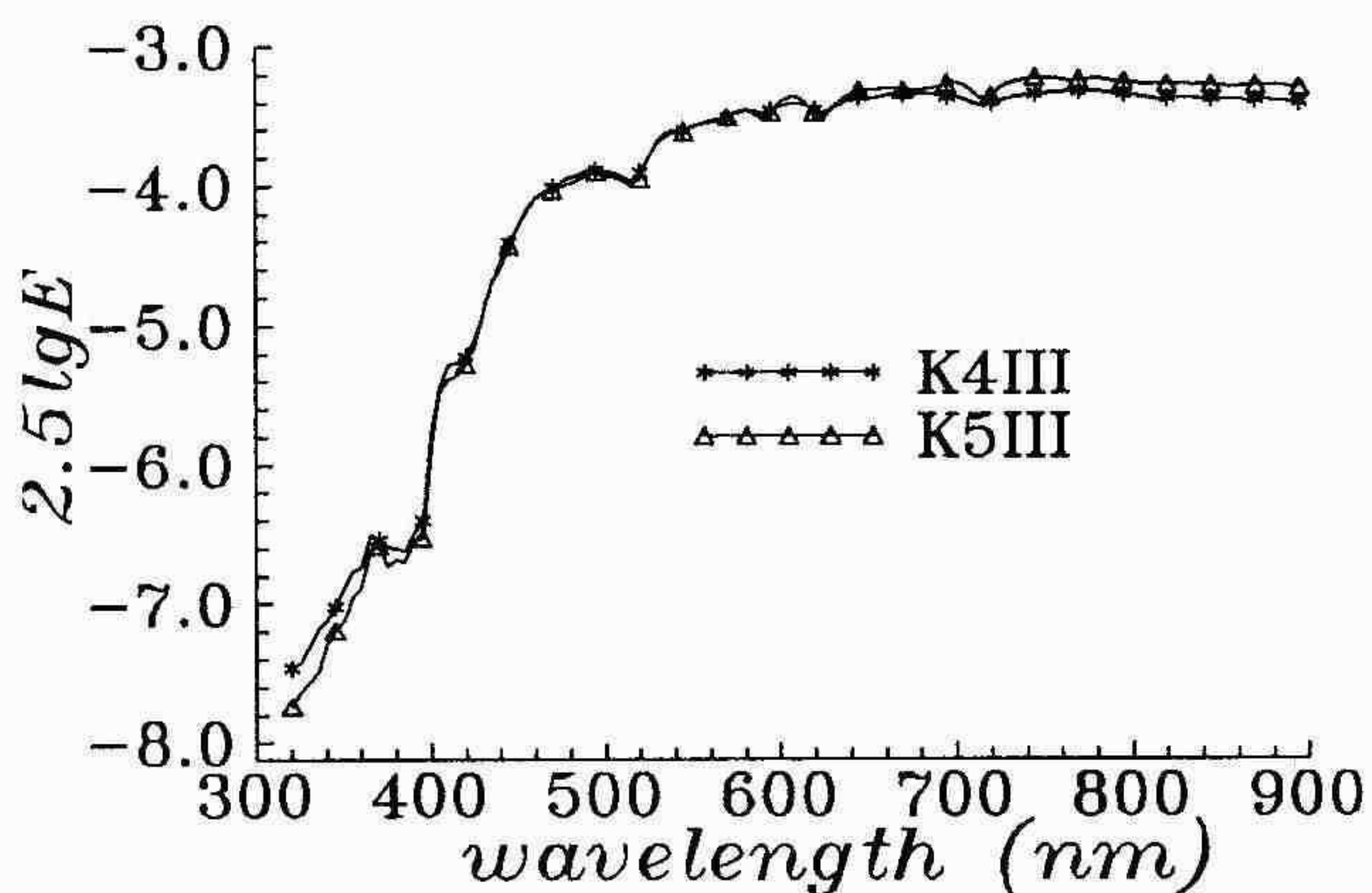


Figure 4. K4III: BS 999, 3249, 3980, 5430, 5563, 5600; K5III: BS 224, 1457, 1654, 3773, 5200, 6705, 7635.

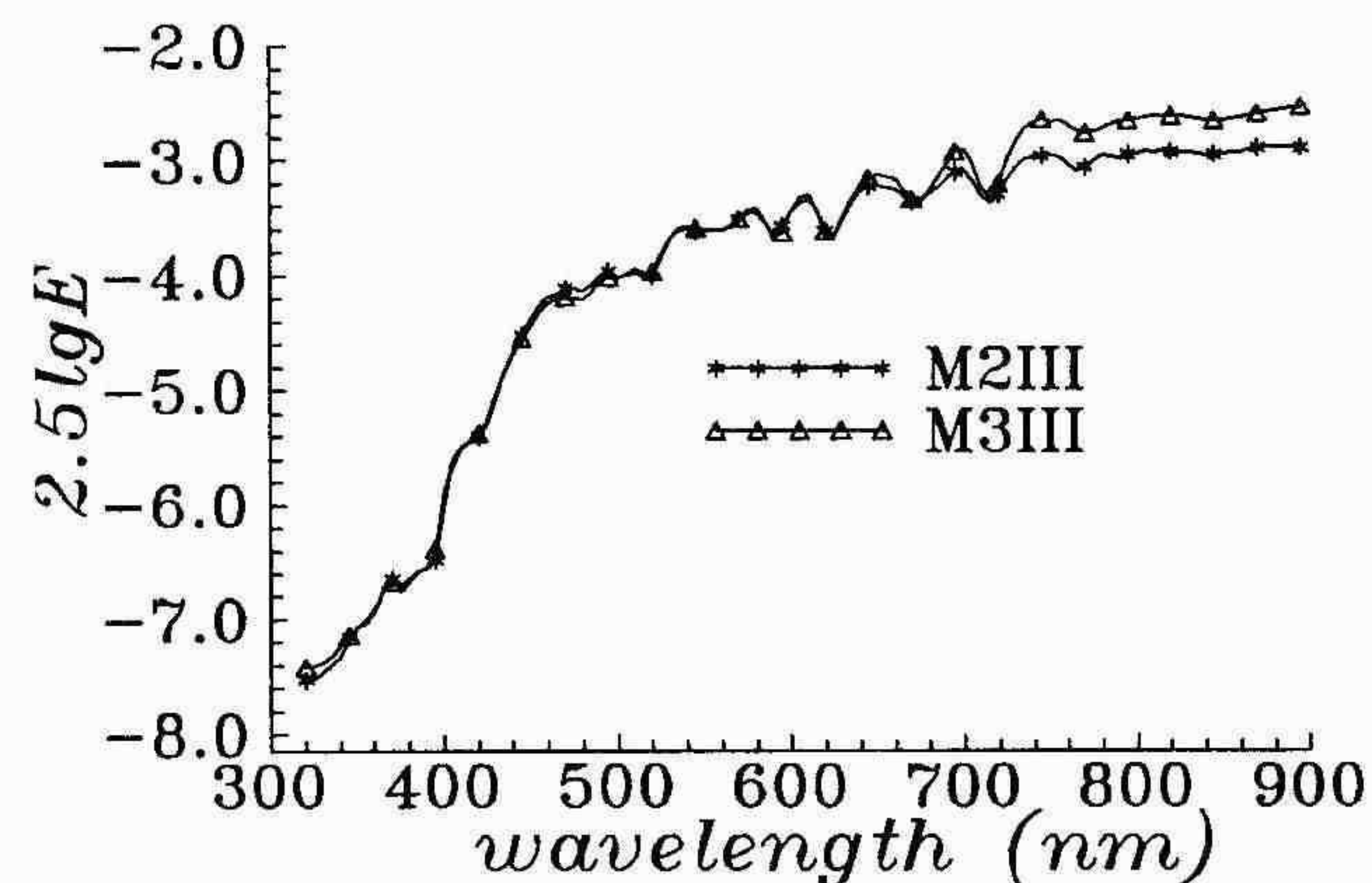


Figure 6. M2III: BS 45, 1162, 3950, 5154, 6200, 8795, 8834; M3III: BS 1451, 4902, 6337, 7951, 9036.

THE ABUNDANCES OF HEAVY ELEMENTS IN THE ATMOSPHERE OF HYADES GIANT δ TAURI

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ABSTRACT. Comparison of synthetic spectrum of the δ Tauri photosphere and high quality spectral atlas of this star permit us to identify absorption lines of iron and heavy elements ($Z \geq 30$) in the observed spectrum. The abundances of 16 heavy elements in the atmosphere of δ Tauri were determined with the differential method of spectrum synthesis. All the abundances are near solar values.

Key words: r —, s —process elements – stellar abundances

The determination of the heavy elements abundances in the stars of different ages allows to investigate the chemical evolution of the Galaxy. δ 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 & Holweger, 1989). Can we detect this enrichment?

Recently the abundances for 7 heavy elements was derived for δ Tauri by Luck & Chalenger (1995) from observations with resolving power 30000. All the abundances was solar, but Cu and Y showed an overabundances near +0.4 dex. The present study is aimed at the determination of the abundances of iron and heavy elements in the photosphere of δ Tauri. A high resolution spectral atlas of this star was published by Gratton et al. (1975). The wavelength regions of the atlas is 3985-4812 Å, resolving power near 110000.

The synthetic spectra were calculated for

K0 III type star and for solar type star within the wavelength range of spectral atlas of δ Tauri with interval of 0.01 Å. Tsymbal (1996) program was used.

For δ Tauri we used the atmosphere model from Bell et al. (1976) grid with parameters: $T_{\text{eff}}=5000$ K, $lg g=2.7$. These parameters were derived by Mishenina et al. (1986) and were used earlier by Gopka et al. (1991). The value of microturbulent velocity $v_{\text{micro}}=1.9$ km/s was obtained in this work from the analysis of equivalent widths of 27 iron lines with solar oscillator strengths (Gurtovenko & Kostik, 1989) reduced to solar iron abundance $lg N(Fe) = 7.50$ in the scale $lg N(H)=12.00$ (Grevesse et al., 1996). For Sun Holweger & Muller (1974) model was used: $T_{\text{eff}}=5770$ K, $lg g=4.44$, $v_{\text{micro}}=1.0$ km/s.

The synthetic spectra in the wide spectral region were used for identification: the unblended and faintly blended absorption lines of iron and heavy elements were selected from calculations. Each line selected from the computed list was investigated in the observed spectrum. The used lines of erbium were identified in the solar spectrum by Gopka & Yushchenko (1995).

The abundances of heavy elements were analyzed with the differential method of spectrum synthesis. Synthetic spectra were broadened by Gaussian type macroturbulence with velocity 5.5 km/s for δ Tauri or 1.8 km/s for Sun and rotation with velocity 1.9 km/s for δ Tauri (Gray & Endal, 1982) or 2 km/s for Sun. Instrumental profiles were assumed to be Gaussians.

Kurucz (1995) SYNTHE spectrum synthe-

Table 1: Lines of heavy elements in the spectrum of δ Tauri

Z	Ident.	λ (Å)	$lg gf$	$\Delta lg gf_{\odot}$	$\%_{\odot}$	$\%_{\delta}$	$\Delta lg N$
30	Zn I	4680.134	-0.81	-0.14	99	98	-.18
	Zn I	4722.153	-0.34	-0.09	100	100	-.09
	Zn I	4810.528	-0.14	-0.06	100	100	-.35
39	Y I	4674.849	-0.46	-0.29	71	97	.17
	Y II	4199.277	-2.15	0.01	75	99	-.03
	Y II	4398.013	-1.00	-0.04	98	100	-.12
40	Zr I	4739.480	0.23	-0.23	88	94	-.18
	Zr I	4772.323	0.04	-0.03	77	95	-.14
	Zr I	4784.913	-0.49	0.03	81	85	-.12
	Zr I	4805.889	-0.42	-0.02	88	83	-.13
	Zr II	4050.316	-1.00	0.07	99	100	-.21
	Zr II	4085.720	-0.12	0.08	87	93	-.11
44	Ru I	4584.443	-0.42	0.01	68	97	.12
49	In I	4511.307	-0.21	-0.04	92	92	-.07
56	Ba II	4130.645	-0.68	-0.16	99	99	-.03
57	La II	4086.709	-0.15	-0.04	100	100	-.16
	La II	4123.218	0.12	-0.05	98	100	-.04
	La II	4322.503	-1.12	-0.01	75	92	-.03
	La II	4662.498	-1.24	-0.04	90	99	.06
58	Ce II	4222.597	-0.30	0.25	98	100	-.13
	Ce II	4364.653	-0.20	-0.02	72	93	.00
	Ce II	4562.359	0.08	0.24	100	100	.17
	Ce II	4628.161	0.01	0.20	99	100	.01
59	Pr II	4408.819	-0.30	-0.07	94	90	.01
60	Nd II	4018.823	-0.89	0.01	97	100	-.07
	Nd II	4109.448	0.30	-0.07	100	100	.03
	Nd II	4446.384	-0.59	0.13	100	100	.07
62	Sm II	4318.927	-0.61	0.18	83	99	.06
63	Eu II	4129.720	0.20	-0.04	<i>hfs</i>	<i>hfs</i>	-.16
64	Gd II	4037.893	-0.49	0.22	100	97	-.11
	Gd II	4085.558	-0.01	0.09	94	98	-.13
66	Dy II	4073.121	-0.10	-0.25	87	98	-.14
	Dy II	4449.704	-1.30	0.24	95	98	-.09
68	Er II	4043.008	-0.86	-0.03	88	98	-.11
	Er II	4048.342	-0.57	0.35	96	87	-.12
76	Os I	4420.468	-1.53	-0.03	83	96	.12
	Os I	4550.409	-0.71	-0.48	66	84	.19

Table 2: Abundances of iron and heavy elements in the atmosphere of δ Tauri

Z	Ident.	$\Delta lg N$	σ	n	Z	Ident.	$\Delta lg N$	σ	n
26	Fe I	0.11	0.12	27	58	Ce II	0.01	0.11	4
30	Zn I	-0.20	0.11	3	59	Pr II	0.01		1
39	Y I	0.17		1	60	Nd II	0.01	0.06	3
	Y II	-0.08	0.05	2	62	Sm II	0.06		1
40	Zr I	-0.14	0.02	4	63	Eu II	-0.16		1
	Zr II	-0.16	0.05	2	64	Gd II	-0.12	0.01	2
44	Ru I	0.12		1	66	Dy II	-0.11	0.03	2
49	In I	-0.07		1	68	Er II	-0.11	0.01	2
56	Ba II	-0.03		1	76	Os I	0.15	0.04	2
57	La II	-0.04	0.08	4					

sis program and automatic spectrum synthesis software URAN (Yushchenko, 1998) were used. All atomic and molecular lines with non-predicted wavelengths and oscillator strengths from Kurucz (1995) database were included in calculations. Hyperfine and isotopic structure data (Kurucz, 1995) were taken into account for europium.

The Sun was used as a comparison star in our work. Deulboille et al. (1984) atlas of solar spectrum was used. The continuum placement in the solar spectrum was corrected in accordance with Rutten & van der Zalm (1984). For all selected lines of heavy elements the solar oscillator strengths were derived for investigated line and for all lines in it's vicinity. These solar oscillator strengths were used for analysis of δ Tauri spectrum.

Line data for heavy elements are shown in Table 1: charges of nuclei, identifications, wavelengths, oscillator strengths, corrections to the oscillator strengths, obtained from the solar spectrum, the ratios of line absorption due to investigated line to the total line absorption at a given wavelength for the solar and δ Tauri spectra (in percents), the abundances of the element in the atmosphere of δ Tauri relative to the Sun calculated for given line.

The mean abundances (relative to Sun) of iron and heavy elements in the atmosphere of δ Tauri relative to the solar ones are gathered in Table 2: charges of nuclei, identifications, relative abundances, mean square errors of relative abundances for one line, number of used lines.

The abundances of iron and 16 heavy elements in the atmosphere of δ Tauri are solar (in the range of errors). The possible enrichment of δ Tauri atmosphere by heavy elements (if exist) is within the box of possible systematic errors due to the uncertainties of spectrum synthesis analysis - less than 0.2 dex. The similar result was obtained for the abundances of 20 heavy elements in the atmosphere of other Hyades giants γ Tauri by Gopka & Yushchenko (1999). Observations of δ Tauri with better signal to noise ratio and highest spectral resolution are desired to obtain a more precise result.

The author are thankful to Dr. L. Delbouille, Dr. A.V. Shavrina and Dr. M.Ya. Orlov for their help in our work with spectral atlases of the Sun and δ Tauri.

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PRELIMINARY RESULTS OF ABUNDANCE DETERMINATION OF IRAS 09276+4454.

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ABSTRACT. The model atmosphere parameters and chemical abundance curve are derived for the infrared source IRAS 09276+4454 identified with the peculiare supergiant HD 82040 (M6). The effective temperature from head band intensity relations of TiO α -system was determined. The abundances of 11 chemical elements in atmosphere of IRAS 09276+4454 were estimated. The chemical abundance pattern is close to the solar one.

Key words: stars: abundances - stars: atmospheres - stars: evolution

1. Introduction

The stars with IRAS-excess are the first candidates in the stars on the post-AGB stage and its chemical composition is of great interest concerning the star evolution.

2. Observations and atmosphere parameters

The observations of IRAS 09276+4454 have been carried out at the 6m telescope echelle spectrometer LYNX (Panchuk et al., 1993). equipped with a CCD of 1040×1160 pixels. The spectral region 7350-7580 Å is relatively free from the molecular line-blanketing and it is used to obtain abundances from atomic lines of Al I, Si I, Ti I, V I, Cr I, Fe I, Co I, Ni I, Y II and Zr I. The sites 5540-5596 and 8065-8210 Å were also used. For all the sites a synthetic spectrum of atomic lines was calculated with the oscillator strengths $\log gf$ from Gurtovenko and Kostyk (1989) and so-

lar model from a new grid model by Kurucz (1993) and compared with the Atlas of the Sun. A synthetic spectrum was calculated by using the program STARSP (Tsymbal, 1993). As a result, the lines, adequately describing a solar spectrum, were selected. For compilation of the line list were involved also the lines from papers of Klochkova and Panchuk (1996), Whitmer et al. (1995), Smith and Lambert (1990). Thus in the list there are about 30 neutral iron lines and 1-4 line of other elements. The level of a continuous spectrum was carried out by a standard method for cold stars - from peaks of intensity on a wide site of a spectrum. For the control of placing a level of a continuous spectrum and estimation of the contribution in absorption of TiO a synthetic spectrum was carried out for selected sites. The effective temperatures were derived from the spectral type Sp - T_{eff} calibrations. The spectral type was derived by a technique, given in paper of Boyarchuk (1969). The method uses the intensity relations of a spectrum with long-wave part of a strip to short-wave at wavelengths of α -system head band strips of TiO ($I_{\lambda+}/I_{\lambda-}$). We employed ($I_{\lambda+}/I_{\lambda-}$) at 4761(2,0), 4804(3,1), 4955(1,0), 5000(2,1), 5167(0,0), 5240(1,1), 5448(0,2) Å for spectral class determination. The averaging of Sp was taken from three spectra (s15735, s15736, s15737). The value is M5. ($I_{\lambda+}/I_{\lambda-}$) and the results of the Sp definition are presented in Table 1. Calibrations Sp - T_{eff} give the following data: a) - 3220 K (Flower, 1975); b) - 3420 K (Ridgway, 1980), c) - 3470 K (Dyck et al., 1996), d) - 3450 K (Fabbri, Richichi, 1997). The surface gravity of the star was esti-

Table 1. The determination of spectral type

$\lambda, \text{\AA}$	s15735	s15736	s15737	Sp
4761	0.20	0.19	0.21	M5.0
4804	0.39	0.34	0.39	M5.0
4955	0.14	0.13	0.12	M4.7
5000	0.39:	0.42:	0.47:	M5.5:
5167	0.13	0.13	0.12	M5.2
5240	0.53:	0.57:	0.59:	M6:
5448	0.31	0.29	0.30	M4.5
5759	0.77	0.76	0.75	M4.5

mated from her luminosity assigned from the effective temperature using evolutionary track calculations from Boothroyd and Sackmann (1988) and the standard formula $\log (g/g_{\odot}) = 4\log (T_{eff}/T_{eff\odot}) - \log (L/L_{\odot}) + \log (M/M_{\odot})$, where the solar parameters $T_{eff} = 5770$ K and $\log g = 4.40$ have been adopted. The value of a mass for this star was assumed $1.2 M_{\odot}$. The obtained value of $\log g = 1.2$. The microturbulent velocity V_t was determined by forcing the abundance of individual FeI lines to be independent of equivalent width. The accuracy of the microturbulent velocity determination is $\pm 0.3 \text{ km s}^{-1}$, $\Delta T_{eff} = \pm 100$ K, $\Delta \log g = \pm 0.3$ dex.

3. Determination of the chemical composition

Determination of the chemical element abundances in atmosphere of the object is carried out under the program WIDTH-9 of Kurucz using the model with parameters $T_{eff} = 3400$ K, $\log g = 1.0$, $V_t = 3 \text{ km s}^{-1}$ and solar metallicity from a grid of atmosphere models of Brown et al. (1989).

The oscillator strengths are taken from Gurtovenko and Kostyk (1989), for a line of Zr I and Y II- from Kurucz, Peytremann (1975). In Table 2 results of determination of chemical composition are given.

4. Discussion of results

As seen from Table 2, the slight deficiency of iron was found. The elements of iron group follow the iron abundance. The overabundance

Table 2. The results of the determination of the chemical composition

El.	n	$\log A$	σ	$\log A_{\odot}$
Al I	3	6.61	.28	6.49
Si I	2	7.68	.19	7.64
Ti I	3	4.47	.15	5.06
V I	1	4.13	-	4.00
Cr I	3	5.53	.35	5.64
Fe I	31	7.28	.26	7.55
Co I	2	4.89	.21	4.92
Ni I	3	6.10	.16	6.22
Cu I	1	3.87	-	4.10
Zr I	4	2.55	.22	2.56
Y II	1	2.36	-	2.24

of Al, Si and Ti underabundance relative to Fe were obtained. The elements of s-process show the abundance near to the solar one.

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THE ENERGY DISTRIBUTIONS IN SPECTRA OF STARS IN REGION $\lambda\lambda$ 320-750 nm

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ABSTRACT. The original energy distributions in visual region of the spectra of 370 stars were received using the method of electrospectrophotometry.

Key words: stars: spectrophotometry, energy distribution

The observations of stellar radiation were received in 70-80 years on observational stations of Odessa Astronomical Observatory - Mayaki (nearly 40 km from Odessa) and on peak Terskol (the Caucasus, height 3100m). The 0.5m- and 0.8m-telescopes were equipped with one-type spectrophotometers. The revision of all data about energy distributions in spectra of stars (E_λ) was made. The comparison of our data with data received on other observatories was made also. The compilative catalogue of averaged data of the energy distributions in spectra of 555 stars in region $\lambda\lambda$ 320–1080nm is the result of this work (Dragunova et al., 1994, Komarov et al., 1995).

However the original averaged and individual energy distributions in spectra of stars also are interesting for investigation of various processes in atmospheres of stars and for estimation of stellar parameters. The disquette-recorded catalogue of 370 stars have been made. The list of BS numbers of stars and number of independent determinations of the energy distributions in stellar spectra made on other Observatories is given. The results of observations received by astronomers of astronomical institutes of Moscow, Pulkovo, Alma-Ata, Crimea were attracted. The r.m.s. of our results does not exceed 5%.

Table. The List of catalogue stars
(BS numbers).

BS	BS	BS	BS
15	622(2)	1409(4)	1865
21	660	1411	1879
39	664(2)	1412(3)	1899(2)
63(1)	707	1457	1903
114	779	1458	1907(1)
153(2)	804(3)	1463	1910
163(2)	834(1)	1478	1931
165(2)	838(2)	1483	1948(4)
168(2)	896	1497(4)	1998(3)
188(2)	911	1543	2002
219	937(2)	1552	2004(3)
253(1)	984	1556	2047
265(1)	1017(3)	1567	2088
269(2)	1030(3)	1580	2095
334(2)	1038(4)	1601	2108
337	1087	1641(2)	2124
395	1122	1656(3)	2286(1)
402(3)	1131	1666	2356(2)
403	1140	1672	2421
437	1142	1689(1)	2429(1)
458	1149	1698(3)	2443
496	1165	1708	2473(1)
509(1)	1178	1713	2484(3)
542(1)	1203	1729	2491(2)
544(2)	1228	1735(2)	2657
545	1251(2)	1756	2777
553	1273	1784	2845
580(2)	1303	1790(4)	2852
595	1329(2)	1791(4)	2890
603(2)	1346(3)	1834	2943(4)
613(1)	1389(2)	1839(2)	2973
617(2)	1396	1852(3)	2985(1)

Table. (*continued*)

BS	BS	BS	BS	BS	BS	BS	BS
2990(4)	4069(2)	4785(1)	5429(1)	6092(2)	6698(3)	7557(4)	8308
3176	4100	4787	5435	6095(1)	6703(1)	7560(2)	8322
3323(2)	4133	4813	5477(2)	6129	6705(1)	7569	8335(2)
3475	4166(1)	4825(3)	5487(3)	6132(2)	6752(1)	7602(1)	8410
3482(2)	4288	4847	5502(2)	6148(3)	6771(3)	7615(1)	8414(4)
3547(2)	4291	4883(2)	5505	6149(2)	6779	7653(1)	8430(2)
3569	4295(2)	4902(1)	5511(3)	6175	6789(1)	7710(3)	8450(2)
3572(1)	4299(1)	4905	5531(2)	6212	6852	7796(3)	8465(3)
3594	4300(1)	4910	5544(2)	6220	6869	7850(1)	8469
3612	4301(2)	4915	5563(2)	6299	6927(2)	7852(2)	8494(2)
3619(1)	4310(1)	4920	5600(1)	6324(2)	7001	7882(4)	8518(3)
3624	4335	4924(1)	5602(1)	6378	7056(1)	7906(2)	8585(2)
3665(2)	4357(4)	4932(2)	5616(1)	6396(3)	7069(1)	7924	8597(2)
3748(3)	4359	4983(1)	5681(1)	6406	7176(2)	7949(4)	8634(2)
3757	4368(1)	5011	5727(1)	6410(1)	7178(2)	7950(3)	8650(3)
3771(1)	4374	5017	5735	6418(2)	7235(2)	7957	8684(3)
3773(1)	4382	5056	5747	6458	7310(2)	7984(1)	8694(2)
3775	4399(1)	5068	5778	6493	7314(2)	7990(2)	8709(3)
3800(1)	4434(1)	5072	5793	6536(3)	7377(4)	8001(2)	8762
3809	4471	5105	5849	6554	7387(2)	8028(2)	8781(4)
3852(2)	4514	5107(2)	5854(3)	6555	7417(3)	8079	8815
3873(3)	4517(2)	5127(2)	5868(1)	6556(3)	7420(3)	8115(3)	8830(1)
3888	4527(1)	5154(2)	5881(4)	6588(1)	7469	8162(3)	8911
3903(1)	4534(2)	5159	5889(2)	6603(3)	7488(1)	8232(3)	8961
3905(2)	4540(4)	5185(2)	5892(2)	6623(2)	7497	8238	8974(3)
3937	4554(4)	5191	5914	6629(3)	7528(3)	8278(3)	
3950(2)	4608(1)	5226	5933(2)				
3975(3)	4660(2)	5235(2)	5968(1)				
3980(1)	4662(2)	5313	5971(2)				
3982(4)	4689(3)	5315(1)	5984				
4031(2)	4716	5338(2)	6018(1)				
4033(2)	4733	5359	6031				
4054	4752	5404(2)	6056(3)				
4057(3)	4757(2)	5409	6075(3)				

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THE PROBLEMS OF DETERMINATION OF ABUNDANCES IN ATMOSPHERES OF K GIANT STARS

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ABSTRACT. The influence of effective temperatures, of surface gravities, of metallicities, of microturbulent velocities as well as of effects non-LTE, of starspotting, of chromosphere, corona and wind, of different nonthermal mechanisms on determination of abundances in atmospheres of cool stars have been discussed briefly.

Key words: Cool giant stars, abundances

The goal of new astrophysics is testing of theories of nucleosynthesis and stellar evolution, chemical and dynamic evolution of the Galaxy based upon data of abundances of chemical elements in diverse object of the Galaxy. In particular, it is necessary to know about abundances of chemical elements and their isotopes in the atmospheres of stars different masses which have passed through this or that stage of evolution. The evolution of abundances are passing prestar - PS, main sequence - MS, first (second etc.) red giant branch - F(S etc.)RGB, horizontal blue or red giant branch - HBGB or HRGB, asymptotic giant branch - AGB, first or second types supernova - I SN or II SN, planetary nebulae - PN and black hole - BH or white dwarf - WD.

So, there are at least four types of stars responsible for abundances of nuclides in the Galaxy (in all the Universe). Their contribution is suggested to change with the Galaxy age, and with that merely partial matter mixing can be expected due to SNI, SNII, N and AGB contribution, and therefore stars of the given metallicity can have various abundances of other elements, in particular, elements of α -process. This problem is discussed in the most perfect and

detailed way by B.Edvardson et al. (1993).

It is clear if the mass loss occurs on early stage lifetime stars on MS that composition of interstar medium will be almost equal to the composition of the initial protostar material.

90% time of life the stars find in phase of MS. Then the red giant phase is last for the majority of stars in which the outer parts expand and cool, while interior slowly transforms into a hot, compact object (a future WD). On small and intermediate masses the core these stars will slowly cool and undergo no nuclear processing. The first time in their life on FBI material processed nucleosynthesis is possibly mix with the material of surface (abundance of Li, Be, B, Na in atmospheres giants and supergiants). Then they become more cool and more luminous (more little value of surface gravity) and material with new chemical composition must be get into space. Such stars have an initial mass - $M_*^i \approx 1-8M_\odot$. The observed masses of WD are $0.55M_\odot$. It means that 97% of all mass interstellar medium comes from low and intermediate mass stars! Only 3% comes from supernova and mass loss from high mass stars. The end such star is outburst type 1 SN. The AGB stars are little to comparison with F(S etc.)RGB stars. IT is clear importance of determination of abundances in atmospheres of G,K,M giant on stage FROG.

In last time is euphoria about accuracy in determination of abundances with using of model atmospheres. The model of star is only the model and nothing more that. The surface of real stars may significant different from model the same as of structure of their outer layers. It is caused not only simplifications by calculation of model of atmospheres:

- plane or spherical geometry;
- local thermodynamic equilibrium;
- various methods of average of coefficient of absorption by frequency
- two-stream mixing-length theory of convection;
- and so on.

but and of real active processes on surface or in outer layers (chromosphere, corona, wind).

The quality of determination of abundances in atmospheres stars must be connected with problems of possible influence of fundamental characteristics of atmospheres of stars as well as of effects:

- non-LTE;
- rotation;
- chromosphere, corona and wind;
- starspotting;
- fluorescence;
- nonthermal of transfer of energy.

The inversion temperature in outer layers of atmospheres giants (Komarov & Shevchuk, 1995) and the short-term fluctuations of emission lines such as MgII (Cuntz et al., 1995) can to support this conclusion. The influence of chromosphere activity effects on determined abundance Li can be demonstrated. The abundances derived from the 6104Å LiI and 6708Å LiI line show discrepancy in spread because they have different depth of formation. It is noted that chromospheric effect is opposite to the model predict: the abundance Li derived on line 6708Å is more than the one derived on line 6104Å. But line 6104 is formed deeper in stellar atmosphere and one is freer from chromospheric effects! It means that the abundances Li derived on line 6708Å is set too high.

The two rules of abundance analysis have:

- use weak lines, where line strength is proportional to abundance;
- work with the main stage of ionization.

These rules minimize the effects of errors in the model, in the damping treatment, in microturbulent velocity.

But often it is necessary to determinate of abundances to use one or to lines of various strength. Their equivalent width depend on microturbulent velocity and value of damping.

These parameters determine very bad. The influence of effective temperature, surface gravity we shall see on example of determination of abundance of Na. The analysis of mistakes shown if $\Delta T \leq \pm 250\text{K}$, $\Delta \log g \leq \pm 0.25$, $\Delta [\text{Fe}/\text{H}] \leq \pm 0.2$ and $\Delta \xi_t \leq \pm 0.15$ then $\Delta \varepsilon(\text{Na}) \leq \pm 0.25\text{dex}$. We must emphasize that method of estimation of right determination of abundances in result non-precision knowledge of fundamental characteristic is purely formal. That characteristics cannot determine of structure of real star so as model of atmosphere of star!

The spectrum of a cool star consists of many thousands of blended lines. The blend are difficult to interpret even of infinite resolution and signal-to noise. But even the device with high signal-to noise detectors and with high resolution spectrographs have two ignored factors:

- the instrumental profile;
- scattered light.

The instrumental profile of any spectrograph give information about the degradation of the real spectra. The projected slit width is independent and instrumental profile is almost constant. But unfortunately ghosts are in strength as the square of the order and they are due to to periodic ruling errors of gratings. The interference of the different systems of ghosts can produce ghosts far from their parent lines.

Scattered light fills in absorption lines and thus produce systematic errors in the profile. The instrumental profile is measured to use a source with narrow lines (Griffin, 1968). The instrumental profile width may change by 10% for various time of observing and region of spectra. The importance of accurate determination of the instrumental profile and the scattered light is very necessary especially at very high S/N.

The $\sim 30\%$ all lines of absorption FeI usually is threw because the abundances determined by this lines are very different from mean value. Why? On Fig.1-3 the scatter of abundances FeI from wavelength for star HD 73710, HD 95689, HD 107328 are given.

Therefore, it is necessary to carefully analyze the structure of a lower level of every absorption line, otherwise can several times overestimate the abundance of element. In the case

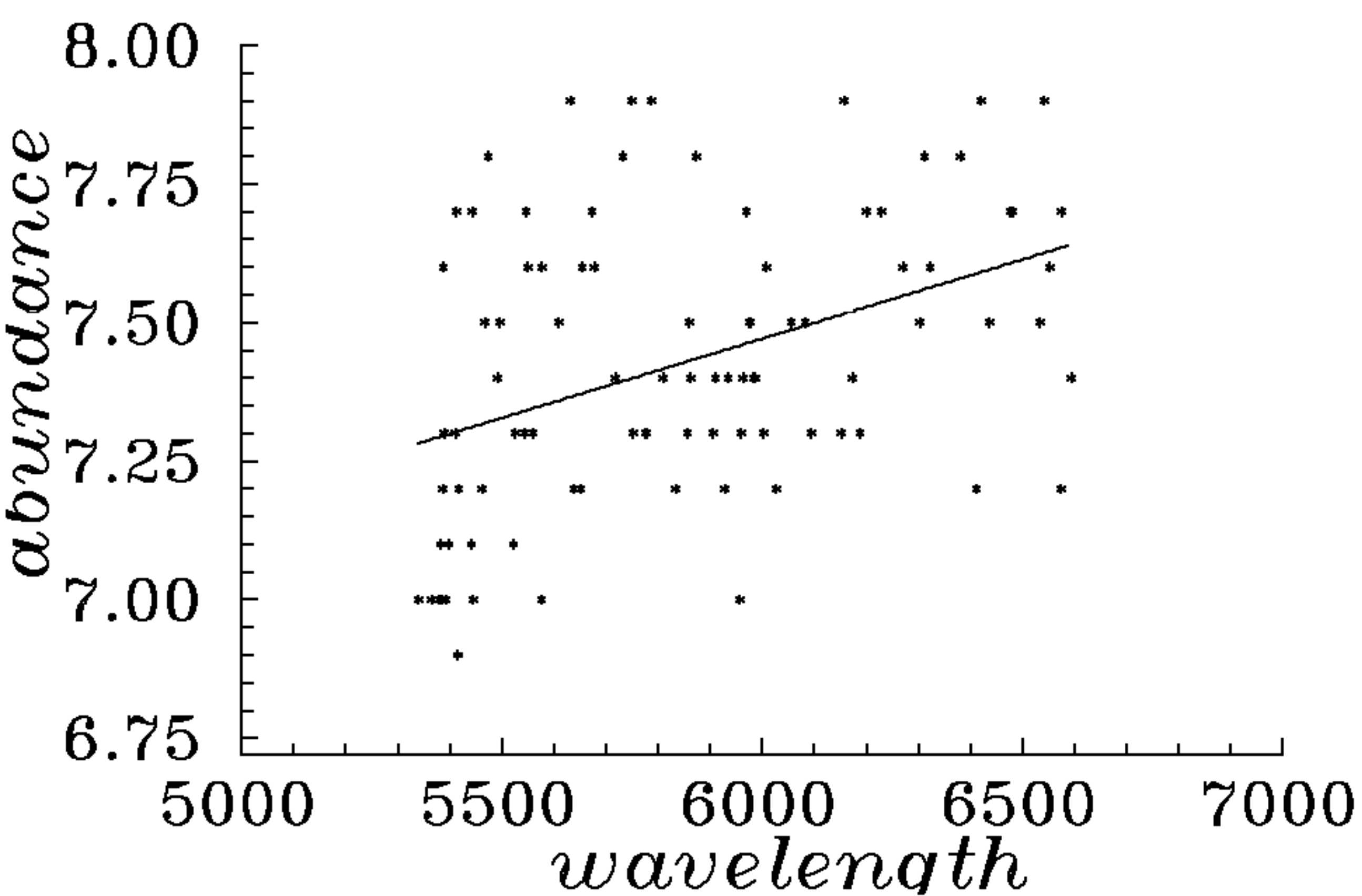


Figure 1. The dependence of abundances $\varepsilon(\text{Fe})$ of wavelength λ for star HD 73710.

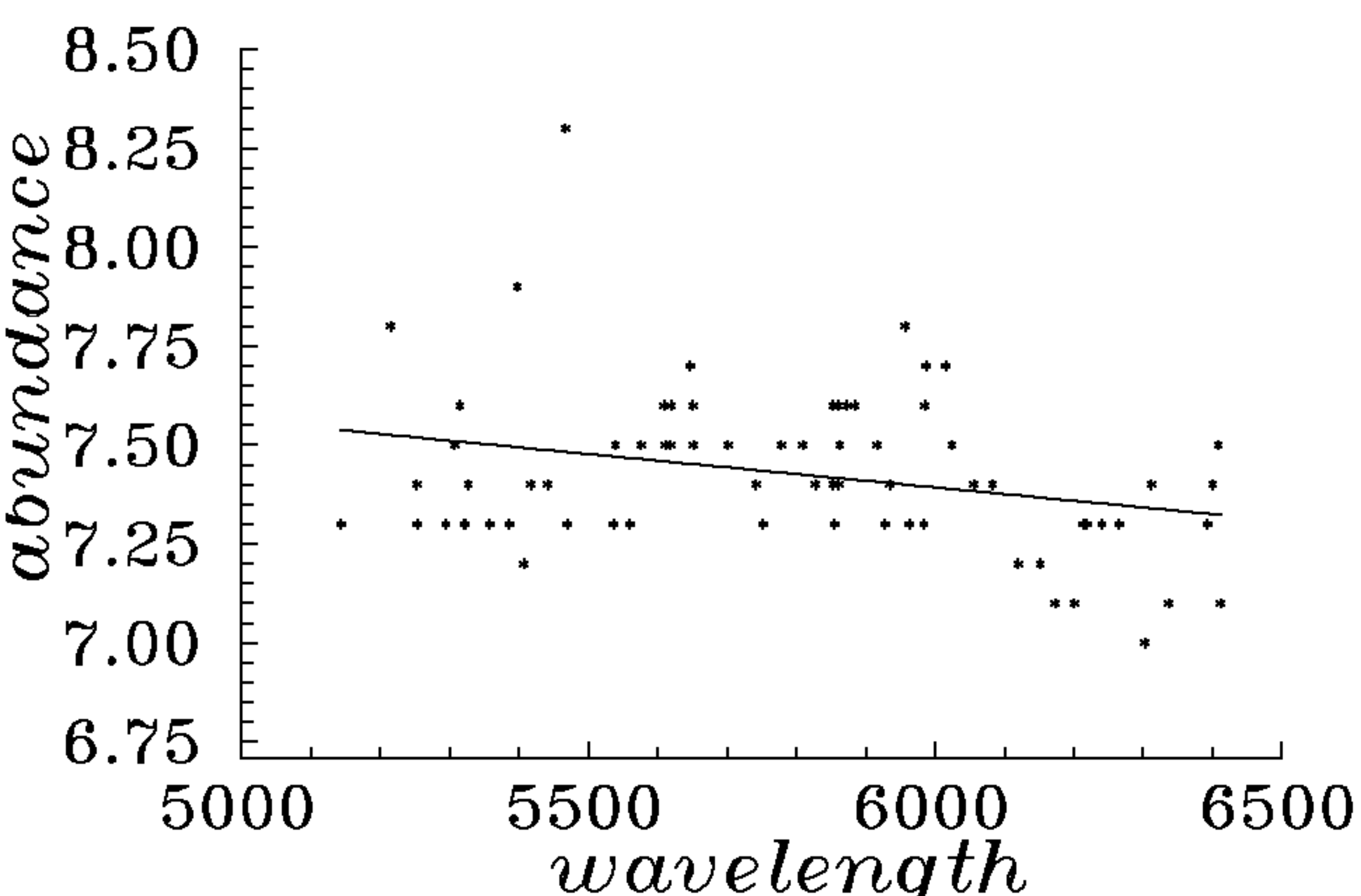


Figure 2. The dependence of abundances $\varepsilon(\text{Fe})$ of wavelength λ for star HD 95689.

of isotopic shift it is necessary to take account of abundance of stable isotopes of a certain chemical element. For the elements of iron group the isotopic shift is occurred since isotopes of elements ^{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, Mg, Al, Si, Ca, Ti, Zr can differ from those of the Earth and give information on their nuclear process resulting from the addition of α - particles and neutrons. The readers will be referred

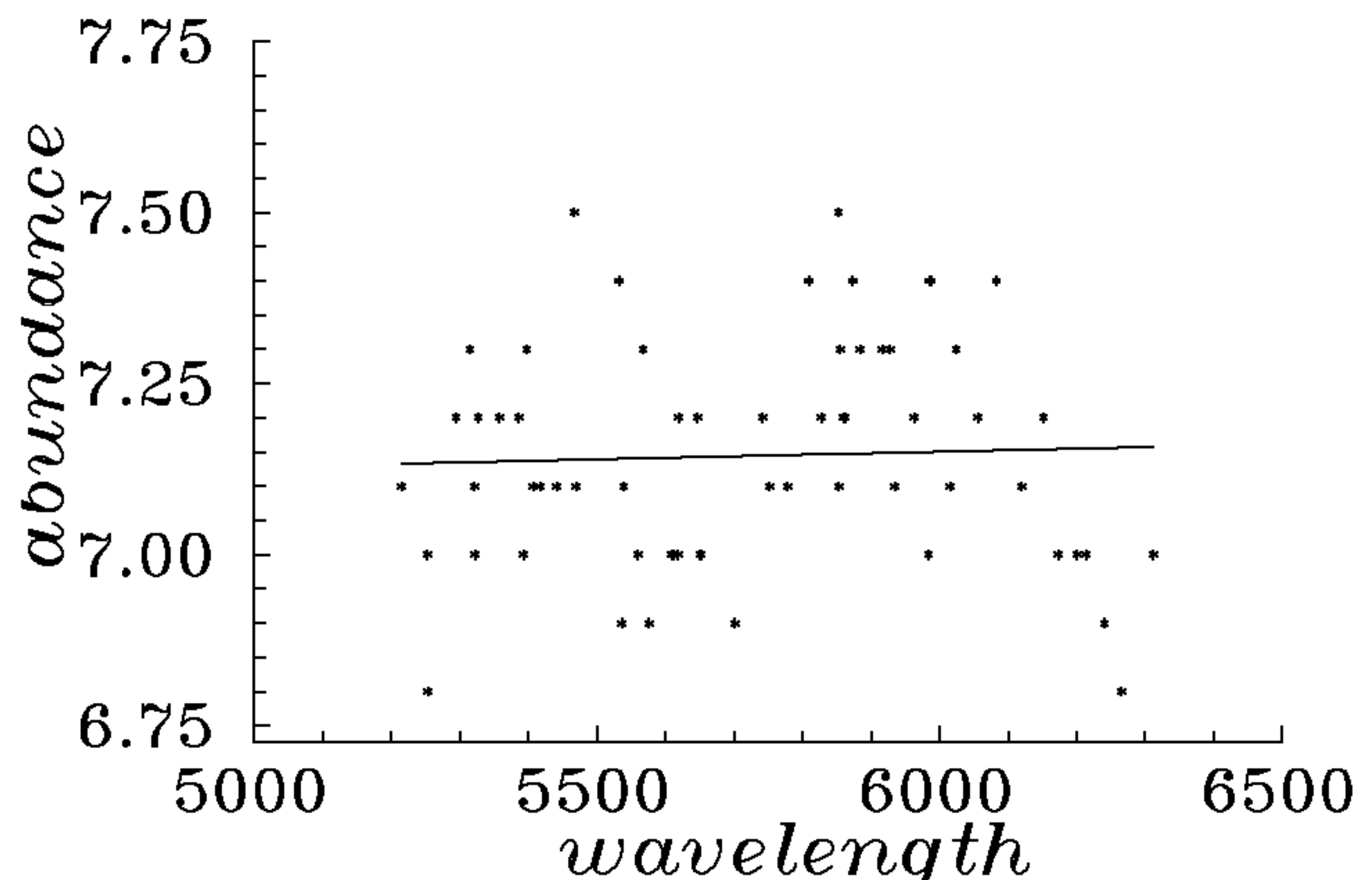


Figure 3. The dependence of abundances $\varepsilon(\text{Fe})$ of wavelength λ for star HD 107328.

to capital reviews by T.Gehren (1988). The mixture of all stable and unstable isotopes is in stellar matter. It means that it is only asymmetric lines in spectra of cool stars because they have all isotopic and hyperfine components. The splitting may cause the errors in results:

- the use of bisectors to determine equivalent widths, microturbulent velocities;
- the use Fourier analysis of line profiles to determine of velocity fields;
- to overestimate of damping constants;
- of mistakes to determine of wavelengths;
- to overestimate of equivalent widths.

The Doppler width and Voigt profile of each isotopes are different. We can to make of mistake to use of Gaussian in the capacity of instrumental profile.

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THE CHEMICAL ABUNDANCES OF ATMOSPHERES OF K GIANT STARS

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ABSTRACT. The abundances of 18 of cool giant stars in vicinity of Sun have been determined. This determination was made by using the method of model atmospheres. It should be noted that almost all elements show discrepancies in abundances determined for absorption lines of atoms and their ions.

Key words: Cool giant stars, abundances, evolution of stars

One of the goal of modern astrophysics is the testing of theories of nucleosynthesis and stellar evolution, chemical evolution of the Galaxy based upon data of abundances of chemical elements in diverse object of the Galaxy. In particular, it is necessary to know about the abundances of chemical elements and their isotopes in the atmospheres of stars different masses and which have passed through this or that stage of evolution.

Stars of the Galactic disk (Population I) were considered to have been formed after 10^9 years' lifetime of our Galaxy. At present, however, stars of Galaxy disk are discovered of the age equal to that of Globular clusters (Komarov et al. 1996).

So, there are at least four types of stars responsible for abundances of nuclides in the Galaxy (in all the Universe). Their contribution is suggested to change with the Galaxy age, and with that merely partial matter mixing can be expected due to SNI, SNII, N and AGB contribution, and therefore stars of the given metallicity can have various abundances of other elements, in particular, elements of α -process. This problem is discussed in the most perfect

and detailed by B.Edvardson et al. (1993).

The information about atmospheres of giant stars are a key to the solution of many problems on the evolution of stars and stellar systems, formation of nuclides with mass more the mass H, enrichment of star atmospheres of heavy and light elements and isotopes. However, here we come across a paradox - the presence of a tremendous number of atomic and molecular lines of absorption permits to determine abundance of many nuclides and, unfortunately, at the same time these mainly hinder both the investigations of parameters of atmospheres of cool giant stars and the construction of mathematical model of atmospheres of stars.

In the Astronomical Observatory of Odessa State University the new data of temperature, gravity, microturbulent velocity, radius, mass and total luminosity of ≈ 2000 G-, K-, M giant stars are obtained (Korotina et al. 1989, Korotina et al. 1992, Komarov et al. 1996).

An attempt has been made by use of creating a catalogue of equivalent widths W_λ of lines of absorption in spectra of cool giant stars on the basis of our observation and of literature sources. It is used of spectral Data with high resolution. The catalogue examination has shown only a few number of stars whose spectra was obtained by different authors. In addition, for common stars have a little quantity of common absorption lines even for Fe peak elements. Therefore, at the first stage the data for investigation was reduced by unified procedure by using model atmospheres and common input physics: wavelength, strength of oscillator,

energies of lower and higher levels. The determination of abundances in atmospheres of oxygen cool giant stars was calculate to use of model atmospheres (Bell 1978) and codes (Tsymbal 1995). The other our data about abundances of chemical elements can be founded Komarov et al. 1985a, Komarov et al. 1985b, Mishenina et al, Gopka et al. 1990a, Gopka & Komarov 1990b, Komarov & Basak 1992, Komarov et al. 1994 and so on. The nuclides of s-process can be synthesized only in the entrails of giant and supergiant stars with $M > 1.5 M_{\odot}$. It is shown, that atmospheres of giant stars of field of the Galaxy disk in spectral range G-K with solar metallicity have almost solar abundances of elements of s-process. The prevalence of metallic-poor giant-stars is characteristics of G8-K1 spectral types, as to giant-stars of K2-K5 spectral types it being vice versa (Korotina et al. 1989) and it have support of our new investigation. It is early to draw ultimate conclusion - excess Na in atmospheres of cool giant stars (Komarov et al. 1985b)- now can notice a constant Na excess tending to enhance from G8 to K4! It is noted that have correlation between abundances Na and luminosities of stars (and namely with gravities) - the larger stellar luminosity conform to greater Na-excess. This correlation may be is due to dependence of luminosity of stars upon its mass or its age. It should be noted that many elements show discrepancies in abundances determined from absorption lines of atoms and there ions. These discrepancies are various for different elements.

In Table 1a, 1b and 1c the abundances of atmospheres of next cool stars are given:

1) HD 2796	5340/2.5/-0.84/2.5
2) HD 4306	5390/3.0/-1.17/1.8
3) HD 6497	4610/2.0/-0.68/2.4
4) HD 35620	4250/1.6/-0.20/2.2
5) HD 37160	4700/2.4/-0.82/1.8
6) HD 43039	4720/2.6/-0.31/1.8
7) HD 49009	4480/2.1/-0.57/2.2
8) HD 68879	4450/2.2/-0.65/2.1
9) HD 95272	4780/2.4/0/2.3

10) HD 95689	4690/2.7/-0.25/1.9
11) NGC 2281 N18	4730/2.3/-0.63/2.2
12) NGC 752 N213	4760/2.6/-0.62/2.4
13) HD 107328	4350/2.1/-0.54/2.4
14) HD 129312	5060/2.6/-0.06/2.5
15) HD 135722	4760/2.6/-0.63/1.7
16) HD 148856	4970/2.8/-0.23/1.9
17) HD 188056	4690/1.9/0/2.2
18) HD 197989	4780/2.5/0/1.6

where are given T_{eff} /log g/[Fe/H], ξ_t -effective temperature, gravity, metallicity - abundance of elements of group Fe to respect of solar one and microturbulent velocity accordingly.

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Table 1a. The abundances in atmospheres of K-giant

El	1	2	3	4	5	6
LiI	-	-	-	-	-	-
NaI	-	-	6.41		5.83	6.35
MgI	6.14	5.99	-	6.69	7.11	6.89
AlI	-	-	7.53	-	-	-
SiI	6.46	6.42	6.80	6.76	7.18	7.16
SiII	-	-	-	7.69	-	8.86
SI	-	-	-	-	7.49	-
CaI	4.33	4.07	6.38	6.29	5.87	5.89
ScI	-	-	3.05	3.34	2.34	2.73
ScII	1.16	1.17	-	2.54	2.45	2.86
TiI	3.37	3.06	4.65	4.98	4.48	4.70
TiII	3.45	3.13	4.64	5.24	4.57	4.54
VI	1.65	1.85	3.86	3.98	3.35	4.08
VII	2.56	1.99	-	-	5.51	-
CrI	3.13	2.96	5.45	6.04	4.95	5.19
CrII	4.19	3.95	5.07	5.82	4.86	5.28
MnI	2.98	2.45	5.30	5.87	4.80	5.47
FeI	5.29	5.00	-	8.76	6.80	-
FeII	5.80	5.14	6.93	7.50	6.81	6.99
CoI	2.96	3.18	7.10	8.07	4.31	7.59
NiI	4.94	4.66	4.51	5.15	5.41	4.52
CuI	-	-	5.73	6.14	4.33	5.82
ZnI	-	-	3.66	-	-	-
SrI	-	-	4.10	4.90	-	-
SrII	0.50	-0.30	1.43	1.36	-	-
YI	-	-	-	-	2.71	-
YII	0.56	0.84	1.41	-	1.14	-
ZrI	-	-	-	2.66	1.57	2.09
ZrII	-	-	-	-	-	-
MoI	-	-	-	-	1.55	-
BaII	-	-	1.40	-	1.28	1.57
LaII	0.30	-0.52	-	-	1.32	1.72
CeII	-	-	-	-	0.50	-
PrII	-	-	-	-	1.18	-
NdII	0.69	0.08	-	-	0.75	-
EuII	-	-	-	0.66	1.23	-

Table 1b. The abundances in atmospheres of K-giant

El	7	8	9	10	11	12
LiI	-	-	1.04	-	-	-
NaI	6.17	6.40	6.53	6.36	6.34	6.22
MgI	7.43	6.28	7.50	7.19	6.31	7.25
AlI	-	-	6.47	-	-	-
SiI	7.60	7.27	7.57	7.65	7.08	7.27
SiII	7.80	8.03	7.75	8.42	8.54	8.58
SI	8.08	8.47	-	-	-	-
CaI	6.19	5.76	6.39	6.22	5.98	5.92
ScI	2.68	2.43	3.18	2.86	2.94	2.32
ScII	3.13	2.74	2.99	3.16	2.56	2.33
TiI	4.82	4.57	5.07	4.85	4.71	4.33
TiII	4.98	3.81	4.89	5.00	4.06	4.38
VI	3.77	3.67	4.10	3.81	3.85	3.56
VII	5.93	-	5.85	6.39	-	-
CrI	5.33	4.95	5.55	5.45	5.08	4.90
CrII	5.61	5.33	5.49	5.78	4.83	5.36
MnI	5.52	5.48	5.82	5.63	5.48	5.30
FeI	7.34	6.91	-	-	-	-
FeII	7.62	7.26	7.46	7.39	6.91	7.01
CoI	4.81	4.49	7.38	7.66	7.44	7.43
NiI	6.03	5.52	4.89	4.80	4.52	4.25
CuI	5.11	3.22	6.06	6.02	5.81	5.77
ZnI	5.12	-	-	4.90	-	-
SrI	-	-	5.10	5.18	-	-
SrII	-	-	3.76	3.88	-	-
YI	2.78	-	3.17	3.08	-	-
YII	1.97	-	2.10	2.17	-	-
ZrI	-	2.03	2.32	2.16	1.84	1.84
ZrII	-	-	2.24	2.14	-	-
MoI	1.91	-	-	-	-	-
BaII	2.15	1.63	1.92	2.20	1.05	0.97
LaII	0.58	1.94	0.85	1.08	1.47	2.03
CeII	1.53	-	1.60	1.73	-	-
PrII	1.87	-	1.82	2.17	-	-
NdII	1.48	-	1.59	2.18	-	-
EuII	-	-	0.32	-	-	-

Table 1c. The abundances in atmospheres of K-giants

El	13	14	15	16	17	18
LiI	1.04	-	-	-	0.79	-
NaI	6.62	5.85	5.95	6.46	7.32	6.37
MgI	7.37	7.10	6.95	-	7.46	7.43
AlI	6.48	-	-	-	7.36	6.33
SiI	7.62	7.47	7.24	7.53	7.94	7.67
SiII	8.06	8.12	7.57	-	8.94	-
SI	7.26	-	7.66	-	-	-
CaI	6.53	5.87	5.98	6.02	6.86	6.22
ScI	3.13	2.44	2.33	2.61	4.28	2.85
ScII	3.24	2.67	2.73	3.03	3.06	3.07
TiI	5.12	4.60	4.44	4.68	5.69	5.02
TiII	5.17	4.79	4.88	4.95	4.66	-
VI	4.06	3.60	3.41	3.69	4.89	3.89
VII	6.06	5.89	5.93	-	5.76	4.14
CrI	5.68	4.97	4.95	5.39	5.94	5.51
CrII	5.83	5.44	5.42	5.74	5.83	5.76
MnI	5.80	5.11	5.10	5.68	6.69	5.74
MnII	7.61	-	6.98	7.43	-	-
FeI	7.70	7.03	7.24	7.76	7.69	7.47
FeII	4.98	7.30	4.42	4.68	7.27	7.58
CoI	6.14	4.69	5.68	6.05	5.50	4.90
NiI	5.08	5.71	4.49	-	6.35	6.14
CuI	5.39	4.52	4.62	-	-	-
ZnI	4.24	-	-	-	6.39	-
SrI	-	-	-	-	4.27	3.28
YI	3.53	2.23	2.71	3.35	3.76	3.00
YII	2.21	1.66	1.57	2.15	2.42	2.36
ZrI	2.43	1.38	1.61	3.01	3.74	2.08
MoI	-	1.53	-	2.74	2.84	2.14
BaI	2.61	-	1.62	2.03	-	2.78
BaII	2.29	2.63	1.73	-	1.57	2.25
LaII	1.36	0.08	0.15	2.41	2.45	2.37
CeII	1.23	0.99	1.31	1.64	1.53	1.77
PrII	1.99	1.40	1.44	1.29	2.29	-
NdII	1.96	0.89	1.21	2.15	2.00	1.56
EuII	-	-	-	-	-	1.37

THE COOL GIANT STARS IN SOLAR VICINITY

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ABSTRACT. The data of absolute spectrophotometry were used for determination of the characteristics for 700 standards' stars in spectral region from G0 to M4. The 170 stars were selected for calibration of new photometric indices obtained by using a multicolour photometric catalogue in Geneva observatory and Gildenkern's systems. Effective temperatures, gravities and metallicities have been determined for 1000 stars of Geneva observatory and for 600 stars of Gildenkern's systems in the region of spectral types from G0 to K5.

Key words: Cool giant stars, evolution of stars

The determination of abundances in the atmospheres of cool stars is associated with the problems:

- of determining their characteristics, i.e. effective temperatures T_{eff} , on gravities on the surface (g), metallicities ($[Fe/H]$), microturbulent velocities ξ_t
- of calculation of model atmospheres adequate to the structure of atmospheres of real stars
- of determining physico-chemical radiation and collision parameters of atoms and molecules (Ridgway et al. 1980, Komarov et al. 1985b, Korotina et al. 1992).

In Tabl. 1-4 are given fundamental characteristics for giant stars of the field in the solar vicinity of Galaxy disk (stars of open clusters and moving groups were excluded). It should be noted that T_{eff} of a star for the same spectral type (at the same spectral index) with small metallicity increases with growth metallicity. This is caused by a large blanketing or blocking effect. This is together with the account of histograms of stellar distribution from spectral types may affect the behaviour of T_{eff} depending on a spectral type, and namely, an

Table 1. The dependence T_{eff} from $[Fe/H]$.

Sp	$[Fe/H] < -0.35$	$[Fe/H] = 0$	$[Fe/H] > 0.1$
G0	5230	5440	
G1	5200	5400	-
G2	5180	5320	-
G3	5140	5280	-
G4	5110	5260	-
G5	5000	5220	-
G6	4860	5140	-
G7	4860	5060	-
G8	4870	5060	5160
G9	4820	5030	-
K0	4770	4950	-
K1	4670	4820	4950
K2	4420	4690	4760
K3	4260	4450	4660
K4	3970	4160	4410
K5	3800	4010	4170
M0	-	3880	-
M1	3720	3800	-
M2	3650	3720	-
M3	3550	3650	-
M4	3440	3500	-
M5	3390	3440	-
M6	3300	3350	-

insignificant variation in T_{eff} in the K6 III – M0 III spectral range results from considerable variation in intensities of molecular bands and other spectral features. Therefore, to attain a smooth run of the T_{eff} the from K6 III to M0 III spectral interval was excluded. Moreover, in the spectral range from K0 III to M0 III variations in mechanisms of energy transfer from inner layers outwards should be expected since in this spectral range there occurs a separation of stars according to the structure of outer envelopes. It is shown that luminosities of giant of stars field of *Galaxy disk* increase with growth metallicities.

When of fundamental characteristics T_{eff} , $\log g$, $[\text{Fe}/\text{H}]$ and M_{bol} of giant stars was became available, the values of luminosities (L), radii $\mathfrak{R}$ and masses ($\mathcal{M}$) were determined for 1370 cool giant-stars and their dependencies on $[\text{Fe}/\text{H}]$ by the coident formulae:

$$M_{bol}^* - M_{bol}^\odot = -2.5 \log(L^*/L^\odot)$$

$$\log(L^*/L^\odot) = 2 \log(\mathfrak{R}^*/\mathfrak{R}^\odot) + 4 \log(T_{eff}^*/T_{eff}^\odot)$$

$$\log(g^*/g^\odot) = \log(\mathcal{M}^*/\mathcal{M}^\odot) - 2 \log(\mathfrak{R}^*/\mathfrak{R}^\odot)$$

With that, for the Sun the following values were accepted:

$M_{bol}^\odot = 4.72, T_{eff}^\odot = 5784\text{K}, \log g^\odot = 4.44$
Luminosities (Tabl.2) of giant stars in the Galactic disk of spectral types from G5 to K5 are markedly different and within 19 to 235 solar luminosities.

Table 2. The dependence $\log(L^*/L^\odot)$ from from $[\text{Fe}/\text{H}]$.

Sp	$[\text{Fe}/\text{H}] < -0.35$	$[\text{Fe}/\text{H}] = 0$	$[\text{Fe}/\text{H}] > 0.1$
G5	1.28	1.34	1.33
G8	1.40	1.46	1.50
K0	1.53	1.59	1.63
K1	1.65	1.71	1.75
K2	1.81	1.87	1.91
K3	1.98	2.04	2.08
K4	2.17	2.23	2.27
K5	2.27	2.33	2.37

The radii (Tabl.3) investigated stars range from 5 to 30 those of the Sun and are nearly independent on metallisities (that is $\log g$ nearly independent on metallisities too). Stars masses practically depend neither on the spectral type nor on chemical composition and amount to 0.7 – 1.3 solar masses (Tabl.4). We must underline it applies only to giant of star field in Galactic disk.

Cool giant stars of the Galactic disk with metallicity increase shift in the HR diagram towards higher temperatures and larges luminosities.

The most impressive result is that for cool giant *field* stars in the Galactic disk, their masses in the G5 – K5 range proved to be statistically less than the solar ones, and consequently, these have the age compared with that of a globular

clusters. Independently, this result was supported Edvardson et al. (1993). In addition, spectroscopic investigations of *visual* binary systems, one component of which is a cool giant-stars, have shown that the mass of these stars is less or equal to that of the Sun (Scalo et al., 1978).

Table 3. The dependence $\log(\mathfrak{R}^*/\mathfrak{R}^\odot)$ from from $[\text{Fe}/\text{H}]$.

Sp	$[\text{Fe}/\text{H}] < -0.35$	$[\text{Fe}/\text{H}] = 0$	$[\text{Fe}/\text{H}] > 0.1$
G5	0.75	0.75	0.74
G8	0.84	0.83	0.84
K0	0.92	0.93	0.94
K1	0.96	1.00	0.98
K2	1.12	1.10	1.11
K3	1.24	1.23	1.21
K4	1.40	1.39	1.36
K5	1.49	1.47	1.46

Table 4. The dependence $\log(\mathcal{M}^*/\mathcal{M}^\odot)$ from $[\text{Fe}/\text{H}]$.

Sp	$[\text{Fe}/\text{H}] < -0.35$	$[\text{Fe}/\text{H}] = 0$	$[\text{Fe}/\text{H}] > 0.1$
G5	-0.03	-0.04	-0.09
G8	-0.06	-0.08	-0.08
K0	-0.08	-0.08	-0.08
K1	-0.06	-0.06	-0.10
K2	0.00	-0.04	-0.03
K3	-0.01	-0.02	-0.07
K4	-0.06	-0.08	-0.14
K5	-0.07	-0.10	-0.13

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CN-STRONG AND CN-WEAK DISK GIANTS

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ABSTRACT. The analysis of the observed abundance of some elements in atmospheres of CN-weak and CN-strong giants is presented.

Key words: stars: abundances - stars: atmospheres - stars: evolution

1. Introduction

CN-strong stars are stars with CN bands abnormally strong for their temperature types and luminosity classes but the stars having the CN bands definitely weaker than the average for stars of the same temperature and luminosity - CN-weak (Keenan, 1987). The question is the blue CN band extended to about λ 4215 Å). Why the giants have positive and negative CN-index? What are causes of these .

2. Observations and atmosphere parameters

For this works we reviewed our investigation of CN-strong giants (Mishenina et al., 1995; Mishenina & Kutsenko, 1996; Mishenina & Tsymbal, 1997) and Luck & Challener (1995) for some CN-strong giants and Luck (1991) for CN-weak. Our observation data were obtained with the coude echelle spectrometer the 1-m telescope of Special Astrophysical Observatory of the Russian Academy of Sciences. Spectroscopic data for stars from Luck (1991), Luck & Challener (1995) were obtained using the Kitt Peak National Observatory coude feed telescope with the coude spectrophotograph and CCD detector system. For analysis we taken the stars with determined CN-index. For three common stars our results of determination of atmosphere parameters and metallicity agree good with the results of Luck & Challener (1995). See Table 1.

Table 1: Comparison of atmosphere parameters of studied stars

HD	T_{eff}	$\log g$	[Fe/H]	Ref
181984	4480	2.0	0.10	our investigation
-	4450	2.3	0.13	Luck & Challener (1995)
185598	4800	2.70	0.07	our investigation
-	4825	2.25	0.04	Luck & Challener (1995)
222404	4810	3.0	-0.02	our investigation
-	4750	3.15	-0.01	Luck & Challener (1995)

CN-index correlations with diverse parameters are given in Figure 1 (a,b,c,d,e,f).

3. Discussion

As can see from Figure 1, the correlations between CN-index and $\log g$, O and Na abundances wasn't, but Fe, O, N abundances observed. Obtained results show that CN-strong giants have C and N overabundances it may be connect with presence of C and N abundance dispersion in pre-stellar matter, and N overabundance may be consequence of deep mixing in giants with positive CN-index.

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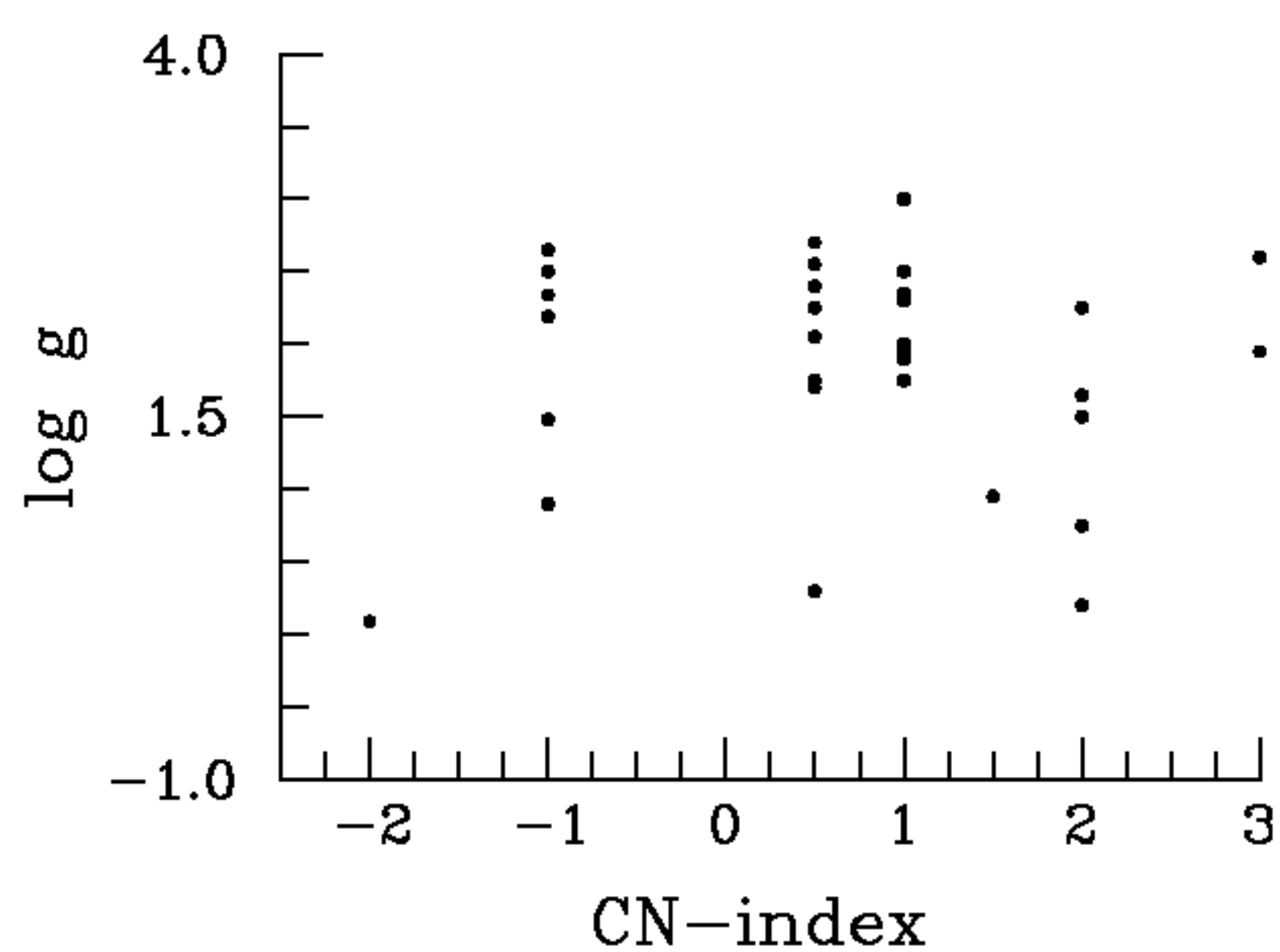


Figure 1a. The relation between $\log g$ and CN-index.

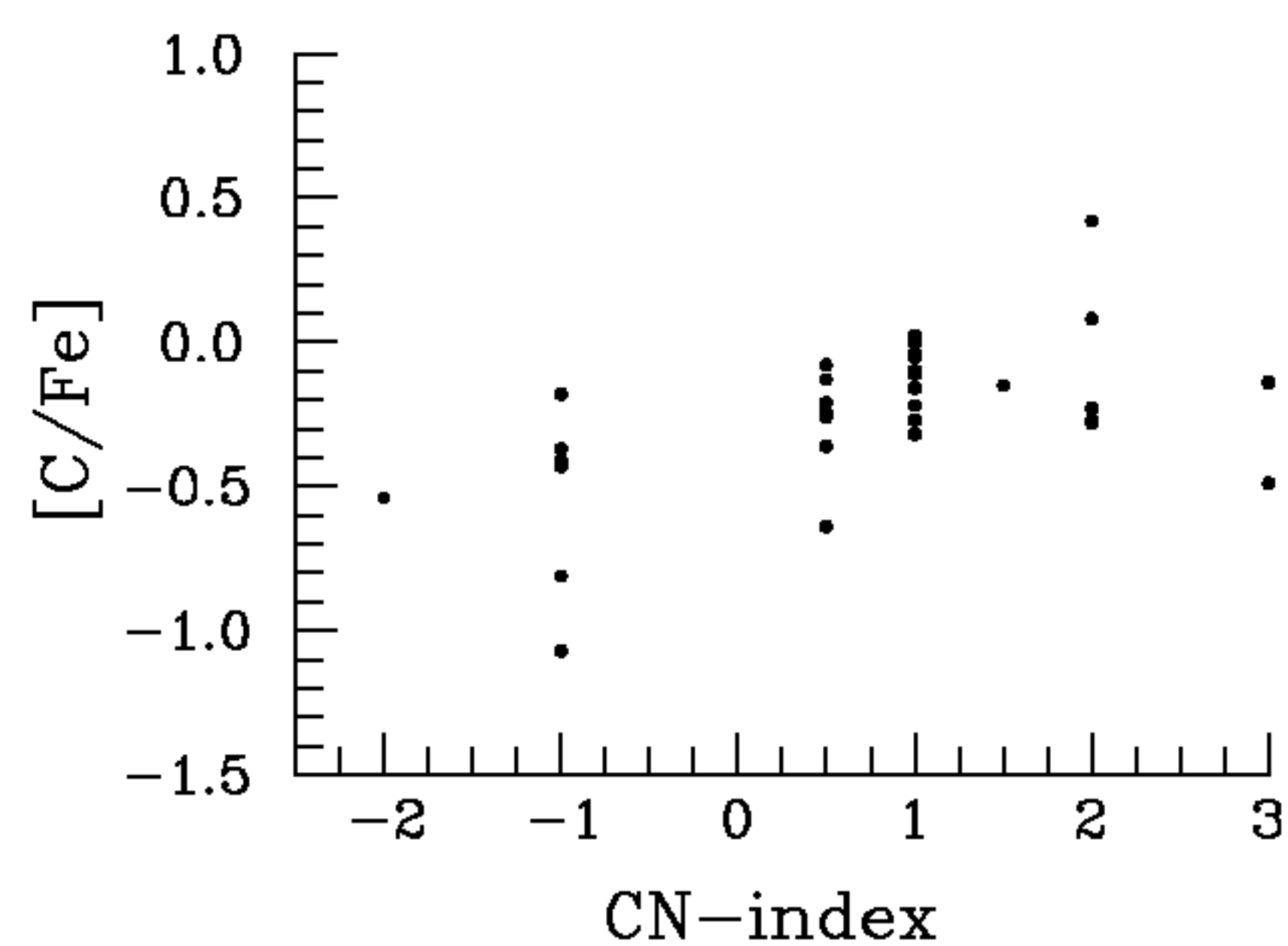


Figure 1d. The relation between $[C/Fe]$ and CN-index.

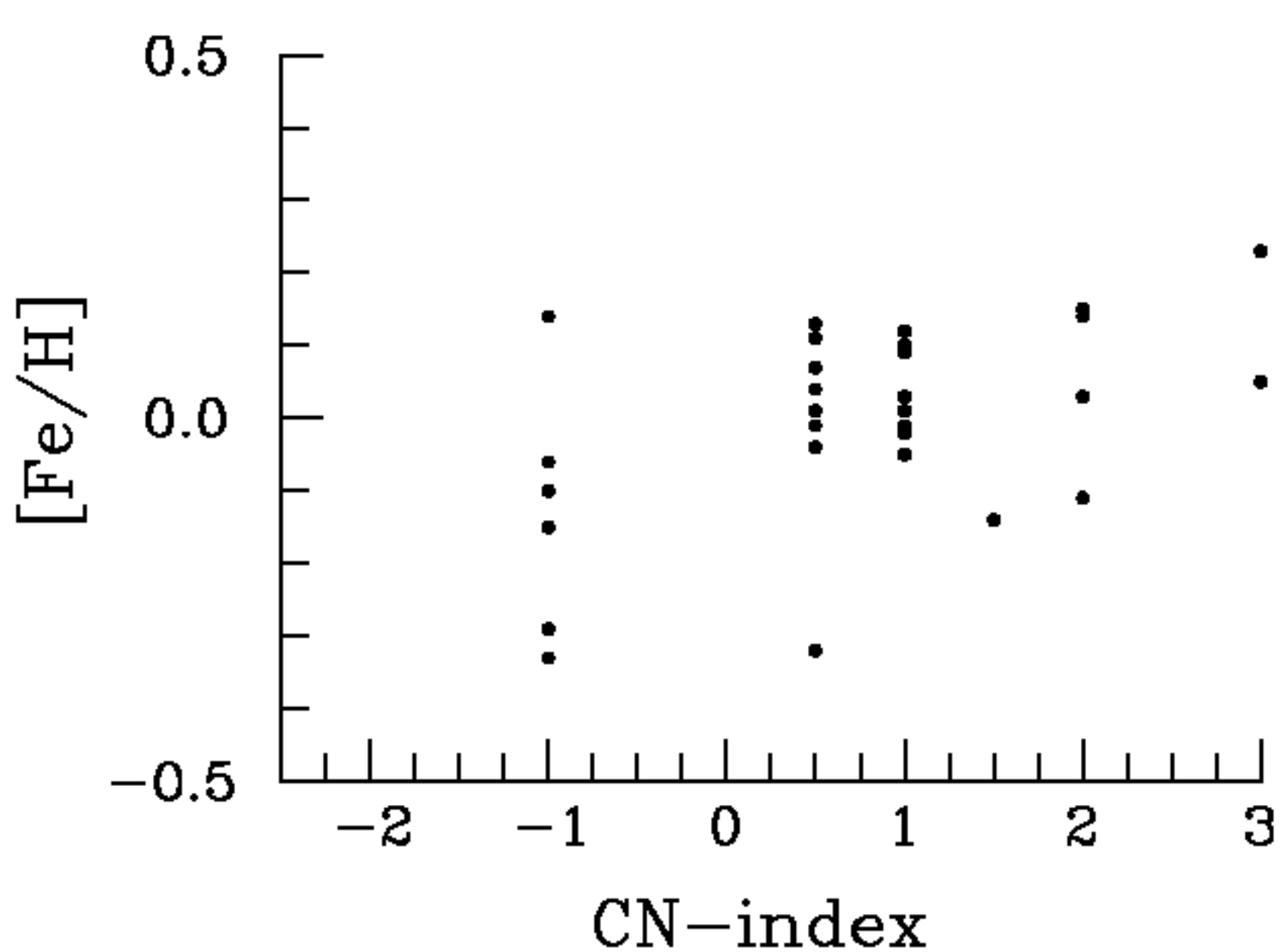


Figure 1b. The relation between $[Fe/H]$ and CN-index.

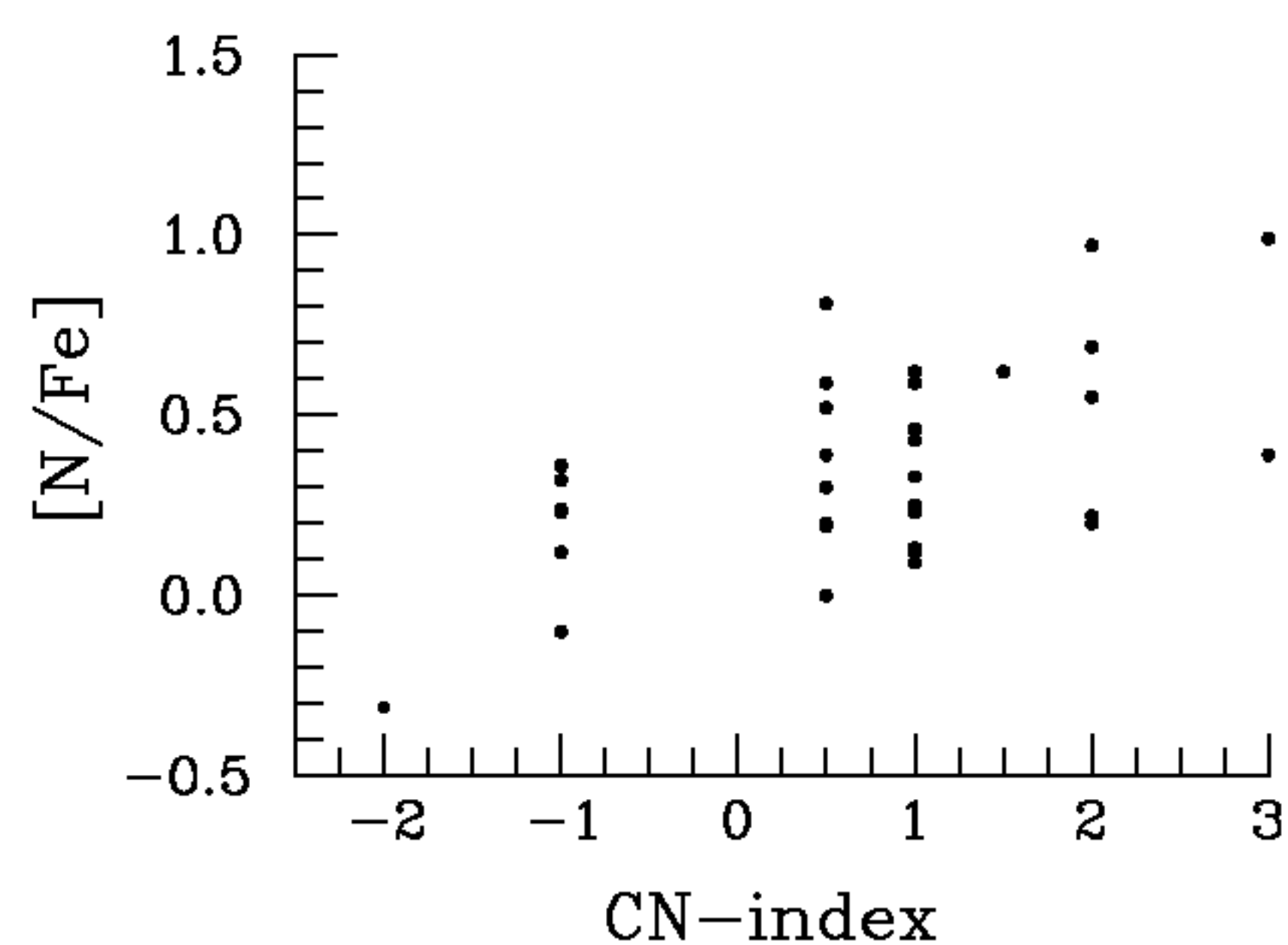


Figure 1e. The relation between $[N/H]$ and CN-index.

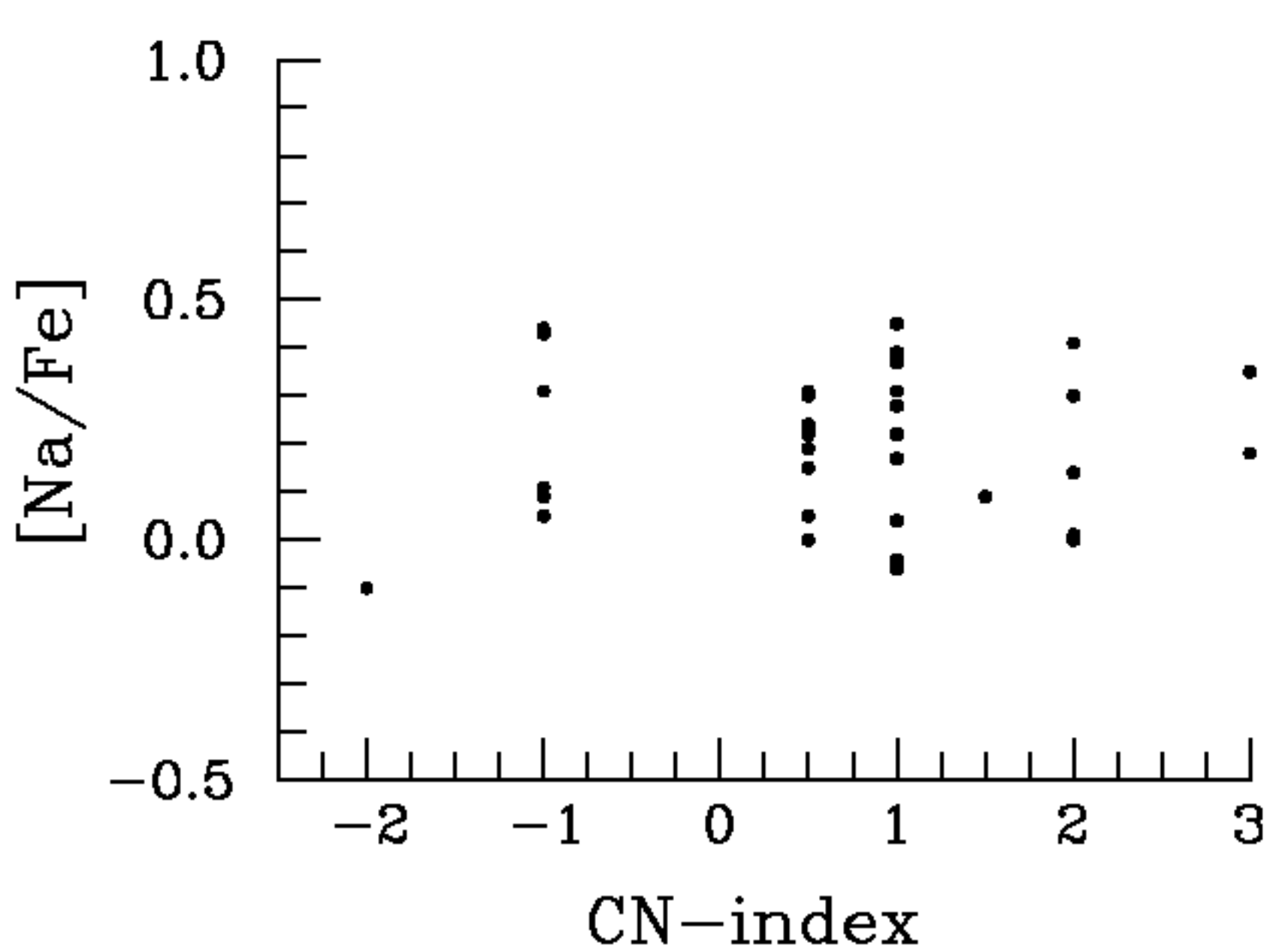


Figure 1c. The relation between $[Na/Fe]$ and CN-index.

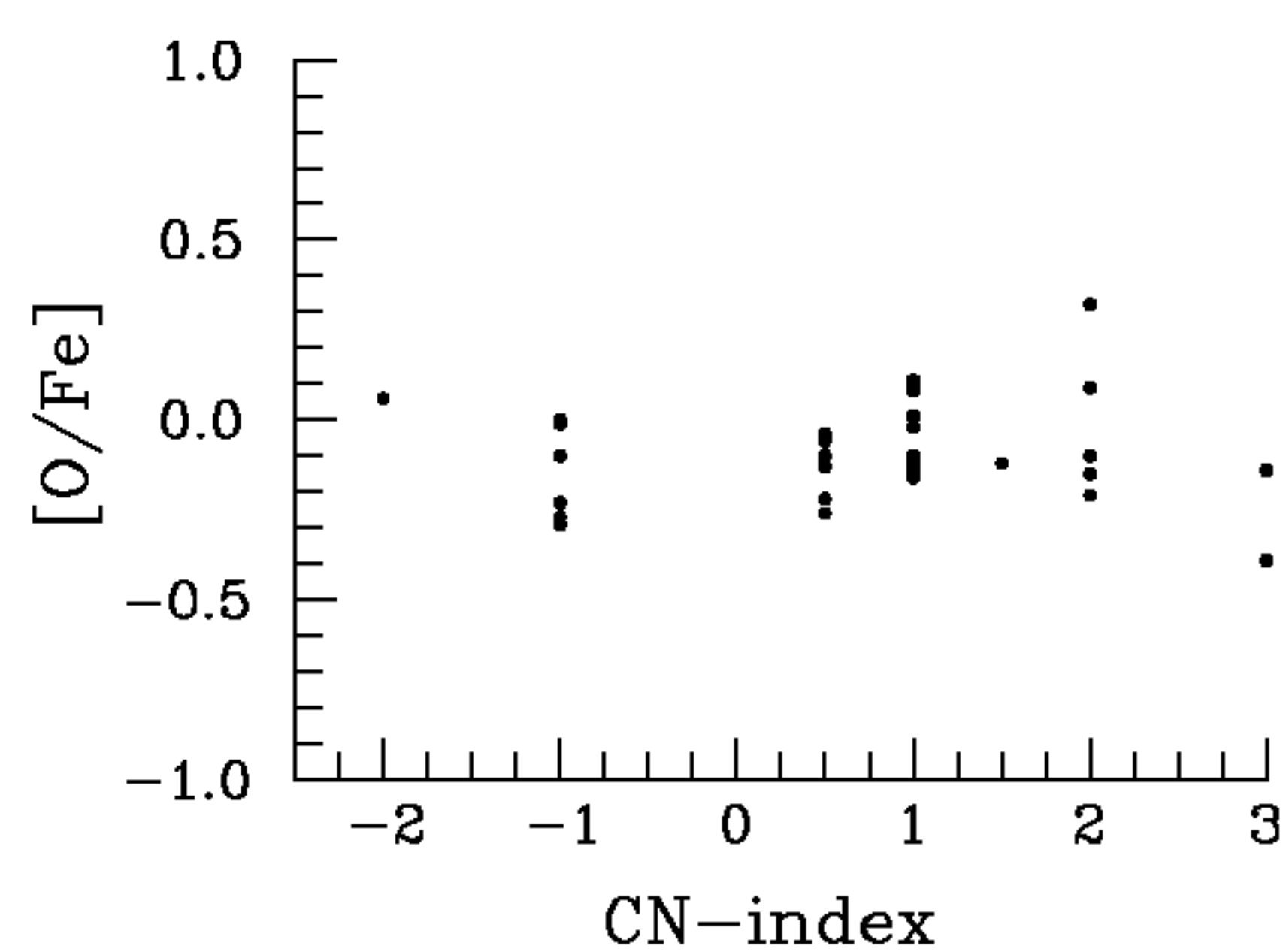


Figure 1f. The relation between $[O/Fe]$ and CN-index.

THE SHELL ACTIVITY OF Be/SHELL STAR ζ TAURI IN 1985 - 1997

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ABSTRACT. The study results of high-resolution CCD-spectra of the V/R variable Be-shell star ζ Tauri covering 1985 - 1997 obtained at the 2.6-m telescope of the Crimean Astrophysical Observatory are present. The equivalent width, the violet and red intensities and V/R ratio of the $H\alpha$ emission line and equivalent width and central depth of the HeII 6678 line were measured. The shell activity was low in 1985-1988: the equivalent width $H\alpha$ emission line were about 7-12 Å, V/R ratio fluctuated in an irregular manner. The active shell phase started in 1989 and then equivalent width of $H\alpha$ emission line increased to 19-26 Å in 1992 - 1995; V/R cyclic changes and compound structure of $H\alpha$ emission line profiles reappeared. In 1996 - 1997 the equivalent width of $H\alpha$ line slightly lessened, but compound profiles structure remained.

Key words: line: profiles - stars: activity - stars: emission line, Be-stars: individual: ζ Tauri

Introduction

The star ζ Tauri (123 Tauri, HD 37202) is one of the brightest and most extensively studied Be/shell stars of northern sky. It is singlelined spectroscopic binary with an orbital period of 132.9735 days (Harmanec, 1984) and cyclic variations of intensities of violet and red peaks the Balmer emission lines (V/R). Its optical spectrum is characterized by rotationally widened HII and HeI lines of an early-B spectral type, by double emission component

of lower members of Balmer series, and by the presence of many strong shell lines corresponding to an A2 Ia spectral type. The strength of the shell lines, the V/R ratio of the double emissions and the radial velocities of the shell lines all exhibit long-term cyclic variations in some epochs. (Hubert-Delplace et al, (1983), Bahng (1976), Slettebak et Reynolds (1978)). Sometimes the cyclic variations disappeared completely (Yang et al (1995)), but the emission and shell spectrum was observed always during century of observations of the star.

The equivalent width of $H\alpha$ emission changed in breadth limits: it was 26-35 Å in 1961-1967 (Delplace, 1970), 19-23 Å in 1973 (Bahng, 1976) and decreased to 12-15 Å in 1984 - 1987 (Guo et al, 1995). In last paper are given parameter variations of $H\alpha$ line from 1978 to 1994 and possible shell models are discussed. In connection with Quirrenbach et al (1994) work as to the reconstruction of ζ Tauri shell in OLBI MarkIII experiment in september - november 1992 into $H\alpha$ line, study parameters of this line obtain special meaning.

Observations

Observations ζ Tauri were obtained by A.E.Tarasov with the spectrograph attached in coude focus of the 2.6-m telescope of the Crimean Astrophysical Observatory. The spectra were registered on GEC CCD P8600 (576×580 pixels) before 1995 and on Elektronix CCD (1024×260 pixels) after 1995. In each observation was registered the spectrum part length

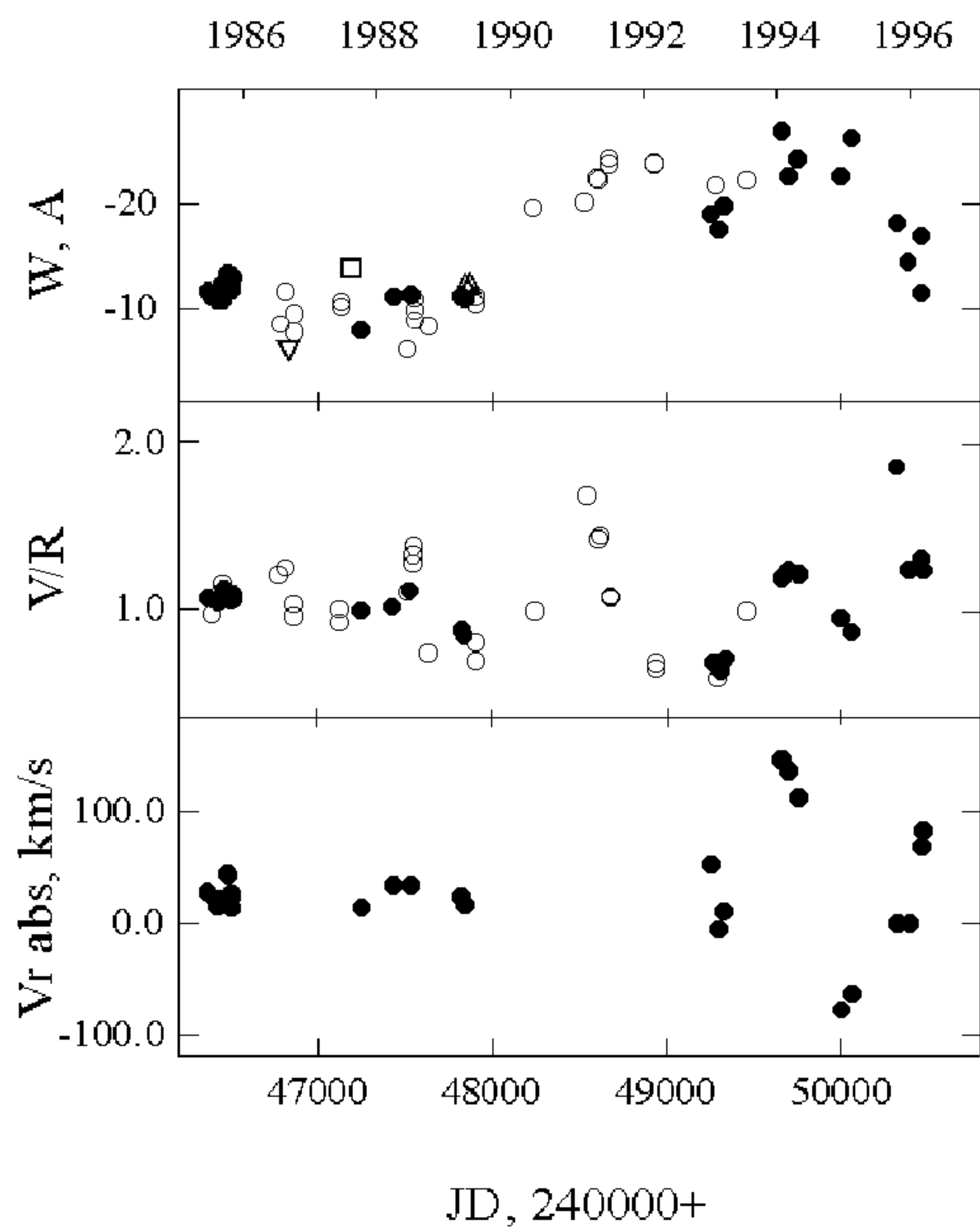


Figure 1. On Fig.1 the our significances of equivalent width of line, V/R ratio, and radial velocity of absorption component intensities are shown as filled circles and:

- circles - Guo et al, (1995);
- square - Mennickent et al, (1994);
- triangles - Kunjaya, Hirata, (1995)

near 60 Å. The exposure times was from 10 to 37 minutes; the signal to noise ratio S/N was 100-200. Whole 29 H α and 11 HeII 6678 was got in 1985 - 1997. The reduction of dates was held in standard manner. Reduction to the lengths waves scale was realized both of the telluric water lines before 1988 and of comparison thorium-argon spectrum; then the fasten lengths wave scale to Solar system barycenter was done. The mean fasten error did not exceed 0.5 km/s.

Line profile variations

We measured equivalent width, the violet and red intensities and V/R ratio of the H α emission line, radial velocity of its emission and absorption component and equivalent width and central depth of the HeII 6678 line. The results are given Tab.1 - 2 accordingly.

Table 1. Measured parameters of H α emission lines ζ Tauri.

JD	W (Å)	I _V	I _R	I _A	V/R
2400000+					
46374.58	11.61	2.31	2.16	1.01	1.07
46405.42	11.01	2.32	2.19	0.93	1.06
46407.41	11.26	2.34	2.20	0.98	1.06
46428.45	10.67	2.24	2.15	0.96	1.04
46460.39	10.75	2.35	2.22	0.88	1.06
46463.30	11.39	2.45	2.26	0.95	1.08
46466.47	12.16	2.52	2.25	1.01	1.12
46490.38	12.21	2.36	2.16	1.25	1.09
46491.35	13.25	2.44	2.26	1.32	1.08
46509.29	12.99	2.38	2.19	1.23	1.09
46510.23	12.48	2.36	2.17	1.28	1.09
46514.29	11.80	2.33	2.20	1.22	1.06
47253.25	7.89	1.85	1.85	0.80	1.00
47436.43	10.98	2.09	2.08	1.38	1.00
47537.50	11.19	2.23	2.01	0.77	1.11
47828.59	11.12	1.93	2.21	0.85	0.87
47846.38	10.79	1.94	2.29	0.75	0.85
49263.61	19.03	2.43	3.56	1.54	0.68
49304.57	17.54	2.26	3.58	1.69	0.63
49340.56	19.78	2.60	3.70	1.70	0.70
49671.29	27.10	3.73	3.13	2.71	1.19
49708.58	22.67	3.40	2.70	2.45	1.23
49762.35	24.40	3.62	2.97	2.53	1.22
50005.61	22.63	2.70	2.85	2.37	0.95
50069.44	26.44	3.70	4.30	2.56	0.86
50326.59	18.16	3.90	2.11	1.90	1.85
50393.63	14.42	2.24	1.81	1.67	1.24
50466.28	17.01	2.73	2.08	1.56	1.31
50472.40	11.42	2.00	1.61	1.49	1.24

The our significances of equivalent width, V/R ratio and radial velocity of absorption component of line are shown on Fig. 1 as filled circles, where the other authors results are shown too (circles - Guo et al, 1995; square - Mennickent et al, 1994; triangles - Kunjaya, Hirata, 1995).

The shell activity of ζ Tauri was low in 1985-1988:

- the equivalent width H α emission line were about 7-12 Å, V/R ratio fluctuated in an irregular manner.

The active shell phase was begun in 1989:

Table 2. Measured parameters
of HeI 6678 line ζ Tauri.

JD	W (Å)	I _A	FWHM (Å)
2400000+			
47199.46	1.6	0.68	3.7*
47436.43	1.8	0.64	3.6*
47537.61	1.32	0.70	1.90
47828.72	1.47	0.69	3.89
47846.53	1.37	0.76	4.50
49263.56	1.29	0.65	1.86
49304.54	1.27	0.69	1.71**
49671.30	1.22	0.81	5.65
50069.46	1.20	0.75	4.00
50393.61	1.55	0.60	2.49
50466.29	1.39	0.60	2.76

* Note: W and FWHM was measured by
dispersion

0.0536 Å/pix without comparison spectrum.

** 0.1057 Å/pix.

-V/R began cyclic changed with slight amplitude at the minimum meanings of equivalent width of H α emission line.

- then equivalent width H α emission line increased to 19-26 Å in 1992 - 1995, the amplitude of V/R cyclic changes increased too and compound structure H α emission line profiles reappeared. Complementary peaks intensity arose. The helium line form and it's radial velocity fluctuated too.

H α emission lines profiles referred to the continuum level are shown on Fig. 2. Three upper profiles relate to low active phase of the shell, and others - to high active phase. That we can see as variety of profiles with it's compound structure.

The similar structures are indicated in the van der Welt work (1970) at the significances W from 28 Å in 1964 to 17 Å in 1966 and there is specified, that H- α radial velocity is remarkable, being reversed with respect to the other hydrogen lines. He assumes positive radial velocity of absorption component as hydrogen ejection from the inner layers. In 1996 - 1997 the equivalent width H α emission line decreased, but compound structure with complemen-

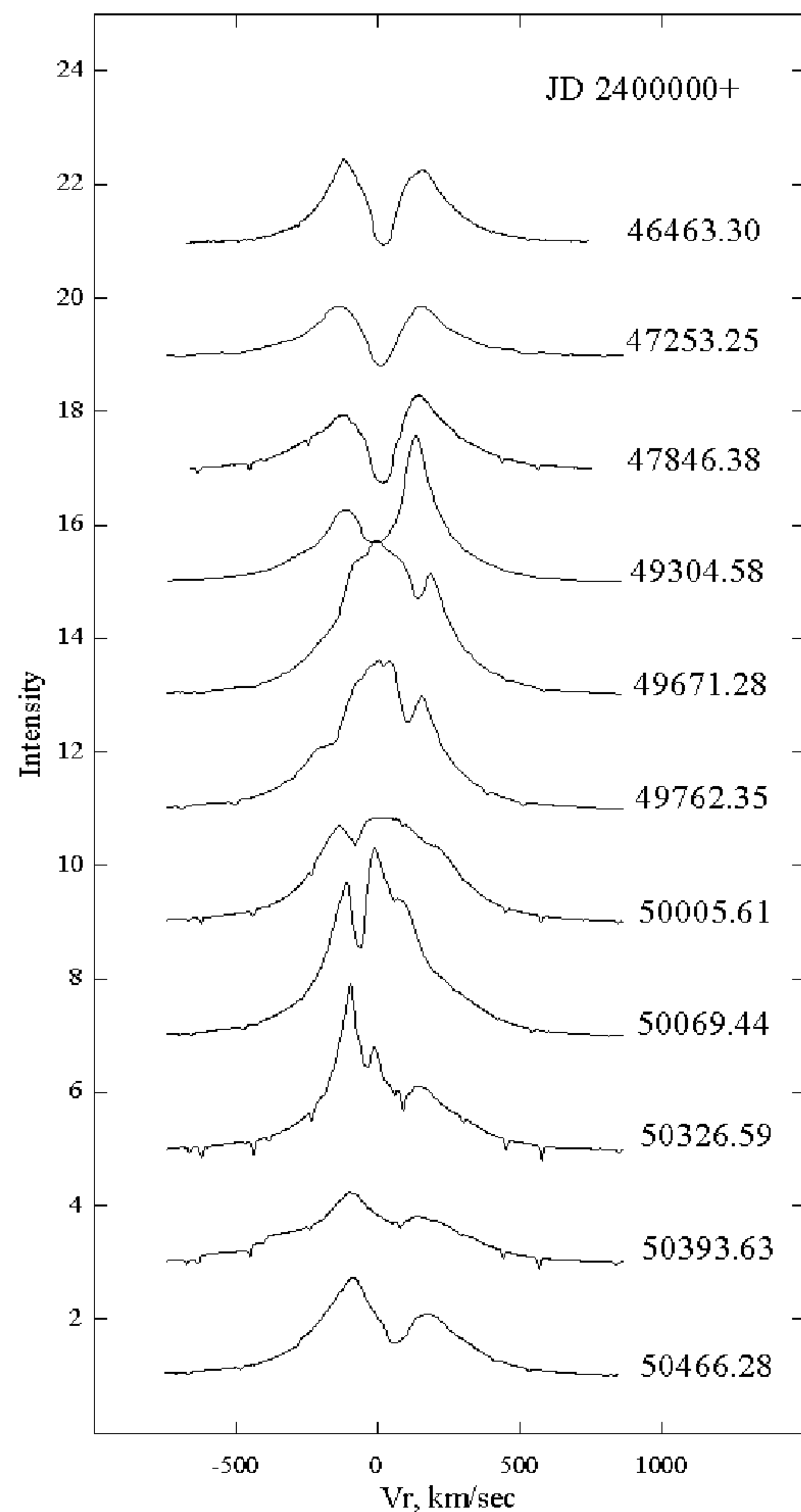


Figure 2. On Fig.2 H-alpha emission lines profiles referred to the continuum level are shown. Three upper profiles relate to low active phase of the shell, and others - to high active phase. Julian dates show of the right.

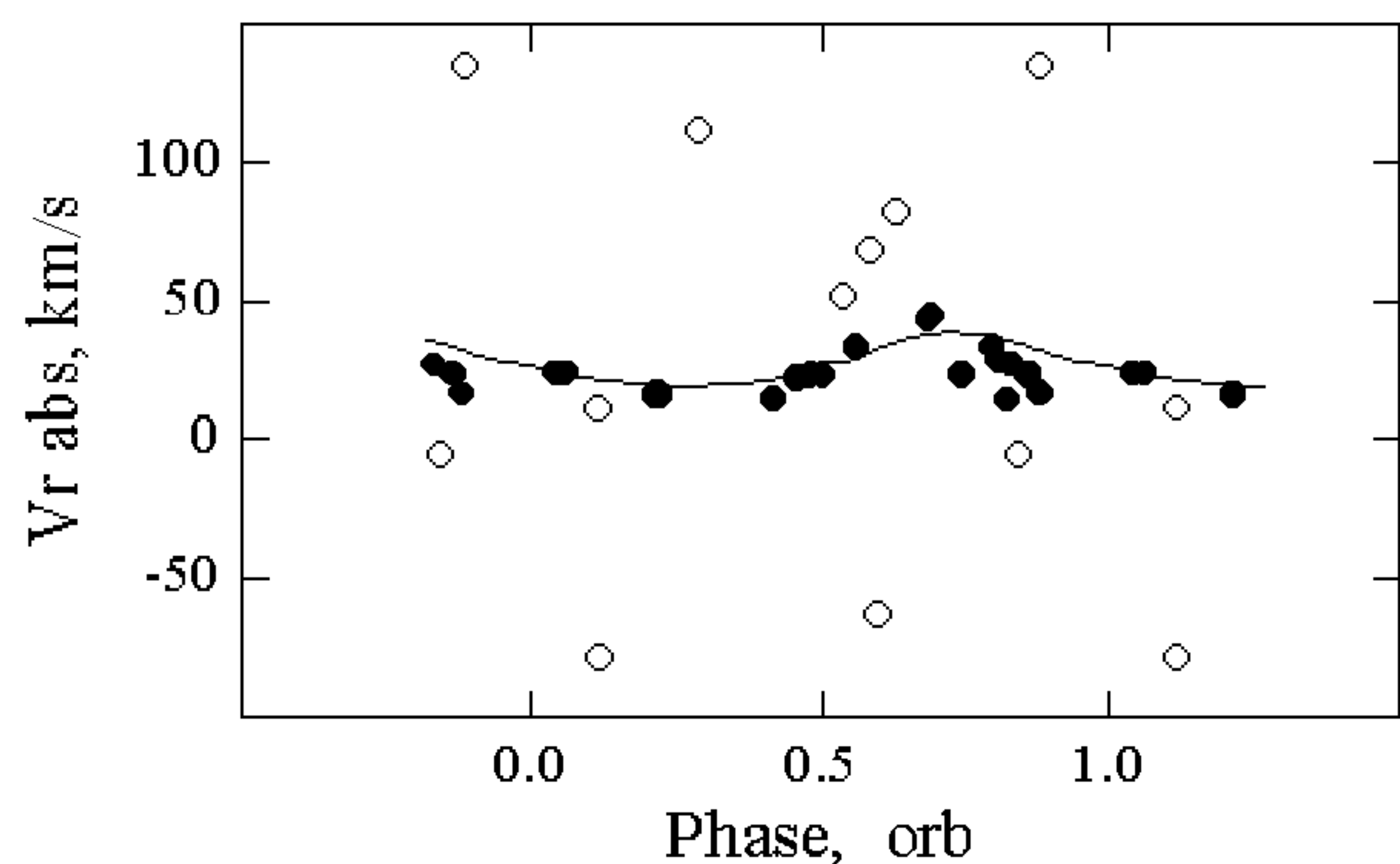


Figure 3. On Fig.3 the radial velocities of absorption component are compared with the orbital movement of ζ Tauri.

- full circles related to calm phase
- circles - active phase
- line - radial velocity of star

tary peaks intensity H α emission remained.

The radial velocity of absorption component also displays dependence from shell activity. At comparison radial velocity of absorption component with the orbital movement of ζ Tauri (the parameters are taken out of paper Harmanec, 1984) we see, that in calm phase radial velocity of absorption component liked to radial velocity of star and changes within 50 km/sec (Fig. 3, full circles). In the active phase the disperse meanings of radial velocity of absorption component achieves 230 km/sec and don't display correlation with the star orbital movement.

Conclusion

The variations of shell size and mass we can observe as variations H α emission and others shell lines. Absorption component is formed in the part of the shell projected against the stellar disk and the Balmer emission lines originate in an extended cool envelope round the underlying star. Therefore, the variations of the radial velocity of shell lines and V/R ratio reflect the behavior of the extended envelope. In an active phase it is possible to assume availability unstable and non-continuous of flows of matter between invisible companion and Be-star.

Existing at present time the shell model of ζ Tauri a most approximate but longtime observations in the different length of the waves of the with allowance for planned repetition of experiment as to the reconstruction of shell will let create more accurate model.

Acknowledgements. I would like thank A.E.Tarasov for data observations and his assistance in preparing this paper. This work was partly supported by CASCA FSU Small Travel Grant.

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DEPLETION OF TiO AND SPECTRA OF THE COOLEST BROWN DWARFS

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ABSTRACT. This study was performed in the context of the "lithium test" for brown dwarfs proposed by Rebolo et al. (1992). We consider the formation of lithium dust species in atmospheres of the coolest stars and substellar objects.

Perspectives on the "lithium test" for the latest M-dwarfs with dusty atmospheres are discussed. Synthetic spectra computed for dusty (Tsuji 1996a) model atmospheres of the coolest M-dwarfs do not show any TiO bands!

Key words: brown dwarfs, lithium abundances, synthetic spectra

Introduction

Low luminosity M-dwarfs close to the bottom of the Main Sequence are the best brown dwarf candidates in young clusters of the solar neighborhood. Rebolo et al.(1992) put forward the idea of *lithium test* for identifying these substellar objects.

Implementation of dust provides drastic changes in the physical state of uppermost layers of atmospheres of the coolest M-dwarfs (see Tsuji et al. (1996a,b), Allard et al. (1996, 1997)). The two largest effects are:

- the temperature structure of model atmosphere may be affected.
- the equation of state should take into account the solid and/or liquid particle formation.

Procedure

The most important change made in this work consists of the new treatment of the molecular-dust equilibrium. Namely, we sug-

gest, that *the specific pressure* $P_i = n_i * k * T$ *cannot exceed the saturation pressure* P_i^{sat} for i-th species. Molecular number densities n_i we get from the solution of the system of ionization-dissociation equilibria equations. Note, the approach gives a lower limit of the impact of the dust formation on the spectra of the coolest dwarfs.

We use two grids of model atmospheres:

- "non-dusty" models with $T_{\text{eff}} > 2700$ K computed by Allard and Hauschildt (1995: AH95) in the frame of classical approaches.
- "dusty" models with $T_{\text{eff}} < 2700$ K computed by Tsuji(1996a).

Results

TiO. In the atmosphere of the $T_{\text{eff}} = 1800$ K dwarf $P(\text{TiO}) \gg P_{\text{sat}}$ (Fig.1). That means the TiO exists here in the non-molecular form mainly! Moreover, we find oversaturated regions for TiO in the model atmosphere of comparative hot stars with $T_{\text{eff}} = 3100$ even for $\log g = 3.5$! Obviously, this effect should give strong impact on the treatment of opacity computations in the coolest model atmospheres.

An importance of the TiO depletion for a realization of the lithium test is obvious. In fact the TiO depletion process improves the feasibility of using of the "lithium test" to tell substellar objects from stars.

Silicon and carbon. Very promising for the forthcoming studies seems the conclusion that in the underphotospheric layers the graphite and silicon dust may be formed.

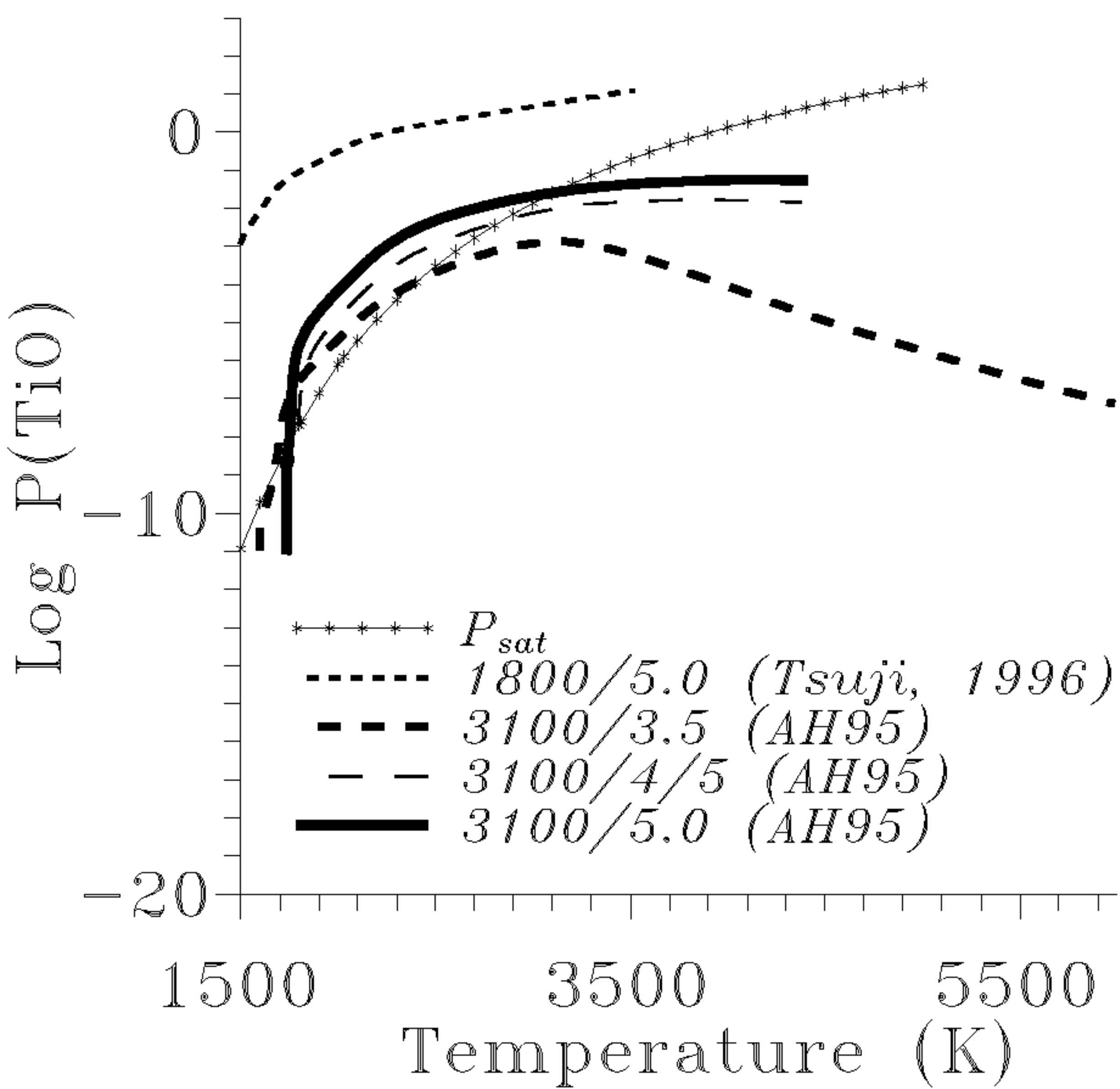


Figure 1. P_{TiO} and P_{TiO}^{sat} pressures in coolest model atmospheres

Conclusions

Finally, let me point out a few important results:

- Li atoms and lithium-contained molecules exist in the coolest model atmospheres in the *undersaturated* regime mainly. *In principle* the lithium dust formation processes cannot affect the Li I line strength.
- TiO molecules are oversaturated even for $T_{\text{eff}} = 3100$ K and $\log g = 3.5$. So the molecular TiO densities should be depleted by the grain formation processes.
- Flux distributions in spectra of the coolest M-dwarfs are severely affected by the TiO depletion. TiO depletion processes reduce its bands strength. Li lines do not disappear under the TiO bands (see Pavlenko 1997 for details).
- Moreover, taking into account a complete depletion of TiO (and VO ?!) we get the "GD 165B - like" (Kirkpatrick et al. 1993) flux distribution in the visible spectrum (Fig.2).
- The yield of the TiO depletion depends on the depth in atmospheres as well on $\log g$. With decreasing $\log g$ the relative strength of lithium lines even increases.

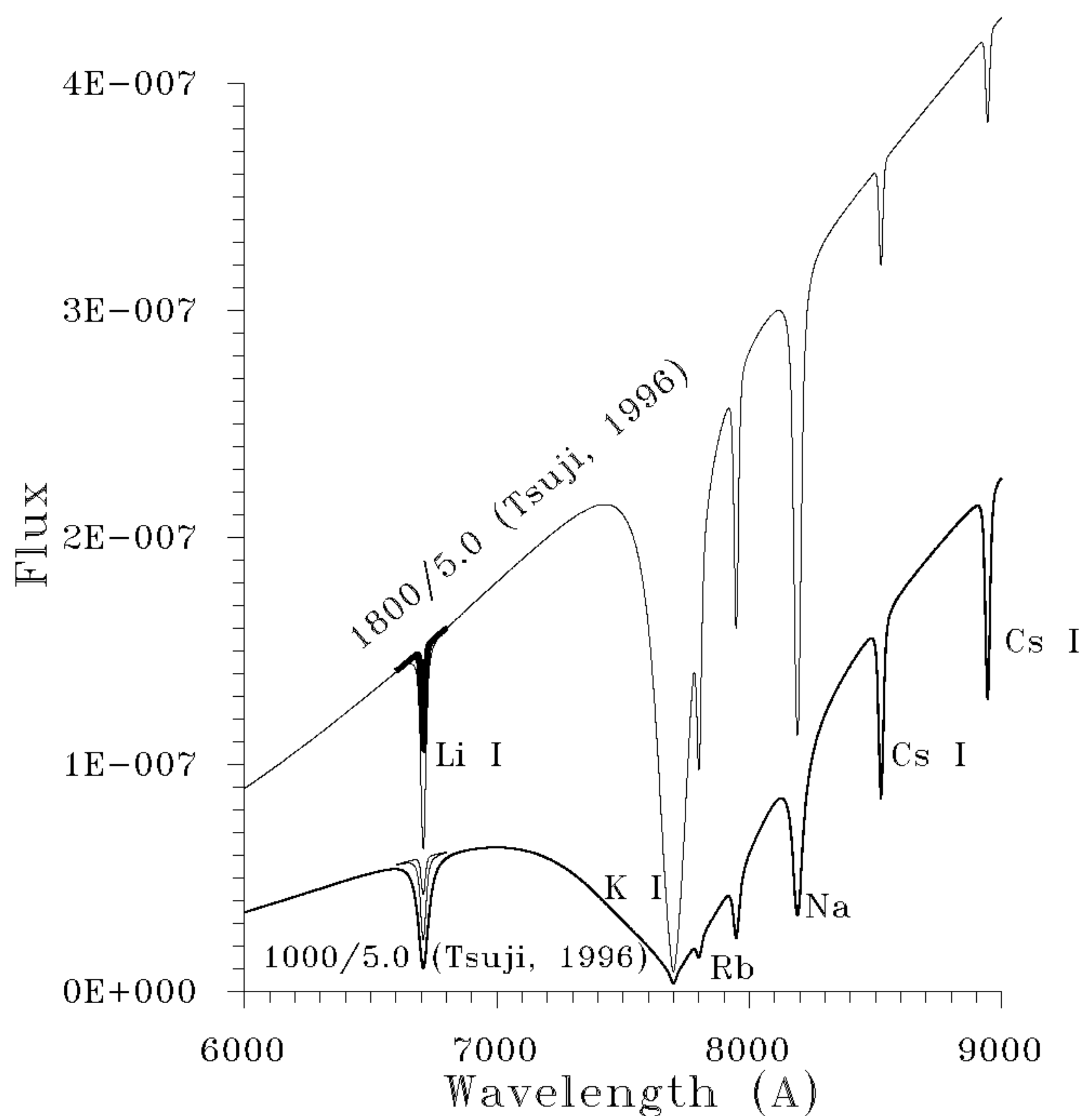


Figure 2. "GD 165 B-like" theoretical spectra computed for 1000/5.0 "dusty" model of Tsuji (1996a) taking into account the complete depletion of VO and TiO. The strongest alkali line positions are labeled in the Fig.

Acknowledgements. Author thanks Profs. T. Tsuji, F. Allard, and P. Hauschildt for kindly providing model atmospheres in digital form.

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CHEMICAL COMPOSITION OF APPROXIMATELY EQUAL MASS Hg-Mn COMPONENTS OF THE SB2 SYSTEM 46 Draconis

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ABSTRACT. We report results of the most complete up to date elemental abundance analysis of approximately equal mass Hg-Mn components of chemically-peculiar SB2 system 46 Dra. The high-dispersion $S/N \geq 200$ CCD spectrum were obtained with the echelle spectrograph of the McDonald Observatory 2.7-m reflector. Lines in the wide spectral region of 3800-9000 Å were identified and the chemical composition of each component was determined for 25 elements. Chemical anomalies of both components are found to be roughly similar: He, C, N, O and Al deficiency, nearly normal abundance of iron-peak elements, large excesses of P, Mn, Ga, Sr, Y, Zr, Ba, Pt, Au and Hg which show a common trend with atomic number. However we found significant abundance differences between the components especially for Ne, Al, S, V, Mn, Ni, Ga, Sr, Zr and Pt.

Key words: Stars: Abundances: 46 Dra

1. Introduction

In recent years the number of studies of Hg-Mn type stars in binary systems have increased considerably. Such stars is of particular interest because duplicity makes it possible to obtain solid data on such fundamental properties as masses and radii as well as on the evolutionary status of these stars. Of special interest is a comparative abundance analysis of SB2 components, because it is crucial in testing the hypotheses of the origin of chemical anomalies. Still more promising would be studies of chemical peculiarities in a binary sy-

stem consisting of components of equal mass, because in that case one could expect both stars to be formed from the same parent matter and to follow a common evolutionary path. Will they have the same chemical composition? Thus, to provide tests for the theories which attempt to explain chemical anomalies one should study subtle differences in the chemical composition of the stars in binary CP systems with equal mass components. 46 Dra provides so far unique laboratory for such purposes due to the small rotational velocities of both components ($V \sin i \leq 5 \text{ km/s}$) and a mass ratio $M_a/M_b = 1.12$ (Adelman et. al. 1997). Only eclipsing binary system AR Aur (Khokhlova et. al. 1995) has so similar components, but rotational velocities of 23 km/s resulting in considerable line blending makes it difficult to obtain a full set of AR Aur A and B abundances. Other known double-lined binaries with Hg-Mn primaries such as HR 4072 (Adelman 1994), X Lup (Wahlgren et. al. 1994) and 112 Her (Ryabchikova et. al. 1996) have much higher M_a/M_b ratios and effective temperature difference between the components of dissimilar peculiarity classes is greater than 1400 K. Thus, among all these systems 46 Dra is of worth studying. Chemical composition of 46 Dra was obtained earlier by Conti (1970) and Guthrie (1984). The most detailed among the previous studies was done by Adelman et.al. (1997, hereafter ARD) using Reticon spectra with $S/N = 200$. ARD obtained light ratio $L_a/L_b = 1.7$ and found solution for the atmospheric parameters of the components using spectrophotometry (Adelman&Pyper 1979), H-gamma profile synthesis, and ionization equ-

Table 1. Known physical parameters of SB2 system 46 Dra.

	46 Dra A	46 Dra B
T_{eff}	11700	11100
$\lg g$	4.0	4.1
[M/H]	+0.2	+0.2
He/H	0.01	0.017
L_a/L_b	1.7	
M_a/M_b	1.12	
R_a/R_b	1.23	
P,d	9.81073(4)	
T_o, JD	2440003.128(32)	
e	0.200(6)	
$K_a, km/s$	26.01(17)	
$K_b, km/s$	29.12(18)	
$\gamma, km/s$	-27.88(9)	

equilibrium condition for FeI and FeII lines. A metallicity of +0.2 dex was assumed for both components.

Table 1 lists atmospheric parameters of 46 Dra determined by ARD as well as orbital elements obtained by Aikman (1976) and refined by ARD.

2. Observations and spectrum reduction

In this study we analysed spectrum of 46 Dra obtained with the echelle spectrograph of the 2.7-m McDonald Observatory telescope using a CCD detector (Tull et. al. 1995). The spectrum were obtained in May 1996 during an observation run held by prof. D.L.Lambert with participation of V.L.Khokhlova. 61 spectral orders covered the wavelength region of 3600-9800 Å with the spectral resolution of 60000. The typical signal-to-noise ratio was $S/N \geq 200$. Initial spectrum reduction was done in the University of Texas by V.Wolff and V.L.Khokhlova with the KPNO-IRAF package. Further reduction and calculations were conducted in the Simferopol University by V.V.Tsymbal and O.P.Kotchoukhov using DECH20 code (Galazutdinov 1994) and STARSP package (Tsymbal 1996). Since spectral orders with Balmer

lines were too short and flat fielding during the initial reduction was not perfect enough we refused from the atmospheric parameters refinement and assumed parameters obtained by ARD with modern analytic technique and observational data. Julian dates for our observations, radial velocities for both components of 46 Dra and phases calculated with the ephemerides given in Table 1 are listed in Table 2.

Since our spectrum covered a wide wavelength range didn't accessible in previous studies we paid much attention to careful spectral lines identification and equivalent widths measurement in order to refine abundances for the elements that were poorly studied earlier or obtain abundances for the species weren't studied at all. We didn't study numerous transitions of Zr and some iron-peak elements (Ti, Cr, Mn and Fe) because their abundances were obtained fairly accurate by ARD who identified many lines of these elements. We performed line identification in spectrum obtained at different phases so atmospheric lines which were not shifting with phase were excluded easily. Equivalent widths were measured mainly in the spectra obtained at the phase of 0.067 when spectral lines of the components were of the best separation. Gaussian profiles were fitted through the metal lines with DECH20 code. A linear regression comparisons of our equivalent widths (in mÅ) with those measured in other studies are given by the following relations:

$$\begin{aligned} W(\text{Conti 1970}) &= 0.855W + 7.973; \\ W(\text{Guthrie 1984}) &= 0.993W + 1.795; \\ W(\text{ARD}) &= 0.943W + 0.238. \end{aligned}$$

3. Abundance analysis

In spectral line identification and chemical composition determination spectrum synthesis technique was used extensively. We performed spectral synthesis with BINARY code which is specially adapted for SB2 composite spectrum synthesis. This code is a part of STARSP package written by V.V.Tsymbal and based on Kurucz's (1993) programs and data.

Table 2. Observational data for 46 Dra.

JD 2450000+	Phase	$V_r(p)$,km/s	$V_r(s)$,km/s	γ , km/s
206.9465	0.067	-58.23	+1.77	-29.92
207.9427	0.169	-41.57	-16.57	-29.78
208.9331	0.270	-24.92	-36.92	-30.58

In addition to HeI lines we used spectral synthesis in determination of Ga abundance from GaII 6334 feature which is severely affected by the hyperfine structure broadening (Lanz et. al. 1993) and in coarse estimation of Hg isotope mixture from HgII 3984 feature. The main body of abundances was obtained with traditional equivalent widths technique using WIDTH9 code. Instead of a widespread equivalent widths correction procedure employed for SB2 spectral analysis we directly calculate equivalent width of a spectral line in a composite spectra using the following formula

$$W_a = \int \frac{F_\lambda^A + S \cdot F_\lambda^B}{F_c^A + S \cdot F_c^B} d\lambda,$$

where $F_\lambda^{A,B}$ and $F_c^{A,B}$ are monochromatic fluxes in a spectral line and continuum respectively computed with model atmospheres adopted and $S=(R_b/R_a)^2$. Therefore our method doesn't require obtaining equivalent width correction coefficient and determining its wavelength dependance. All model atmospheres that we used were generated with Kurucz's ATLAS9 code and OPDF tables (Kurucz 1993). We paid particular attention to the choosing of iteration cutoff criterion. Since integral fluxes 1% error cutoff leads to significant errors in elemental abundances especially for those derived from strong lines, we continue iterations till temperature's error decreases to 1% in every atmospheric layer. Besides in model atmosphere calculations it is important to account for He deficiency. In our study we used models generated with real He abundances obtained by ARD. Accounting for He deficiency changes FeI/FeII ratio, therefore one can suspect "ionization equilibrium" method of atmospheric parameters refinement to be sensible to He abundance. Full results of our line-spectrum analysis with equivalent

widths measured, abundances derived and atomic data for each identified line will be published elsewhere. Compares our abundances with those of ARD are of good agreement and discrepancies rarely achieve 0.3 dex.

4. Discussion

The summary of chemical composition anomalies for both components of 46 Dra is shown on Fig.1a. Components' abundances look very similar except of small discrepancies for Ne, Al, S, V, Ni and Zr, and significant abundance differences for Mn, Ga, Sr and Pt. In addition we found significant difference for the mercury's isotopic composition: in the primary's atmosphere nearly all (85%) the Hg is in the form of the ^{202}Hg isotope, but in the secondary the heaviest stable isotope ^{204}Hg dominates reaching 81% from all the Hg abundance. The secondary's Hg isotopic mixture resembles those of another Hg-Mn component of a SB2 system-X Lup (Guthrie 1984). It is interesting to compare abundances determined for the components of 46 Dra with those of similar SB2 system AR Aur (Khokhlova et. al. 1995). Both SB2 systems have approximately equal mass main sequence components of spectral class near B9V and rotation synchronized with the orbital motion. So it is natural to suggest 46 Dra and AR Aur to have the similar evolutionary history. Fig.1a and b show that chemical compositions of 46 Dra A and B are much alike than those of AR Aur components. But in both cases the same elements show abundance differences between the components: Al and Ni deficiency, Mn, Sr and Y overabundance are different for the components in both systems. As for heavy elements like Ba, Pt and Hg they behave very different in 46 Dra and AR Aur: the latter has much

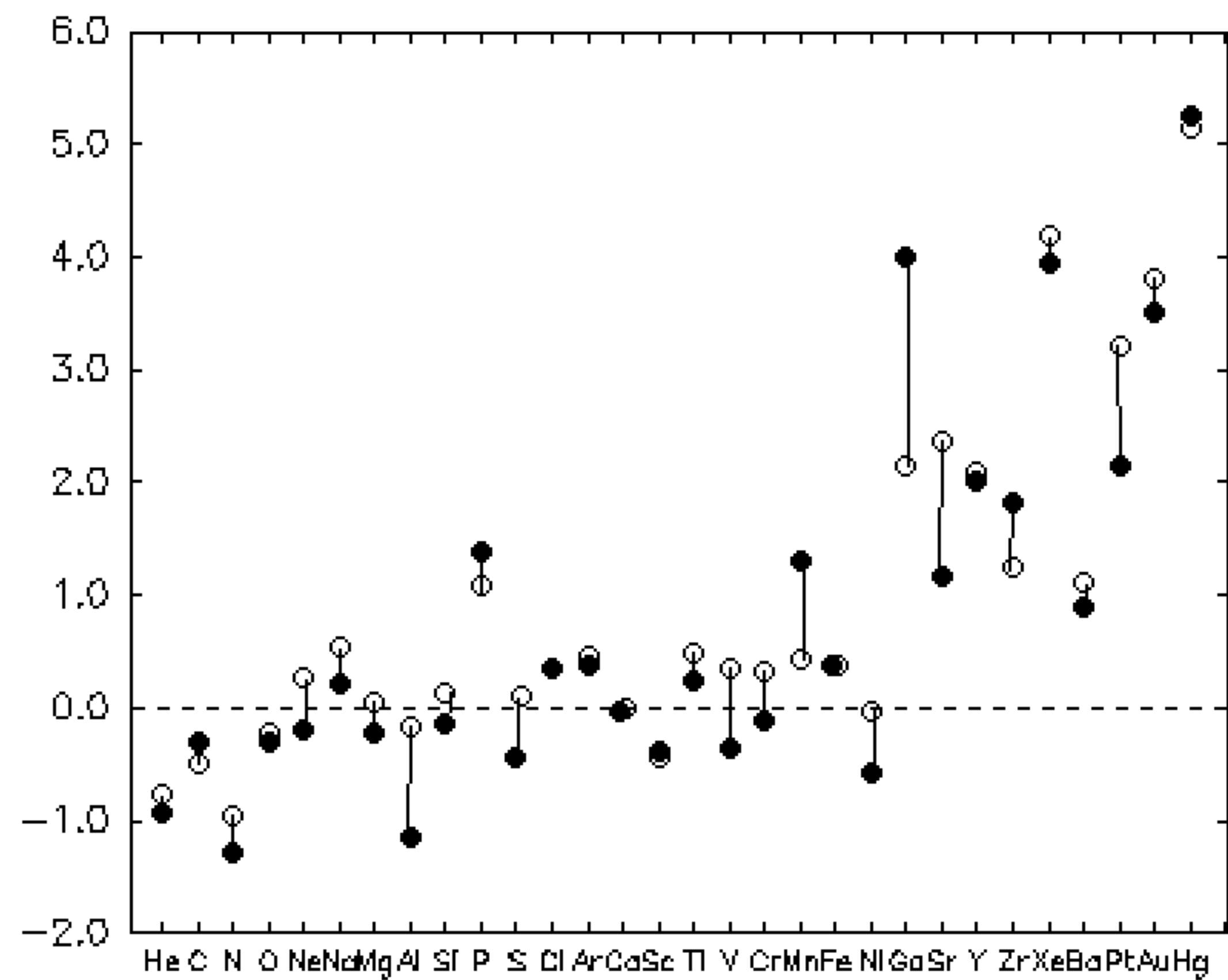


Fig. 1a. Abundances derived for 46 Dra A (filled circles) and B (open circles). The solar abundance is indicated by a horizontal dashed line.

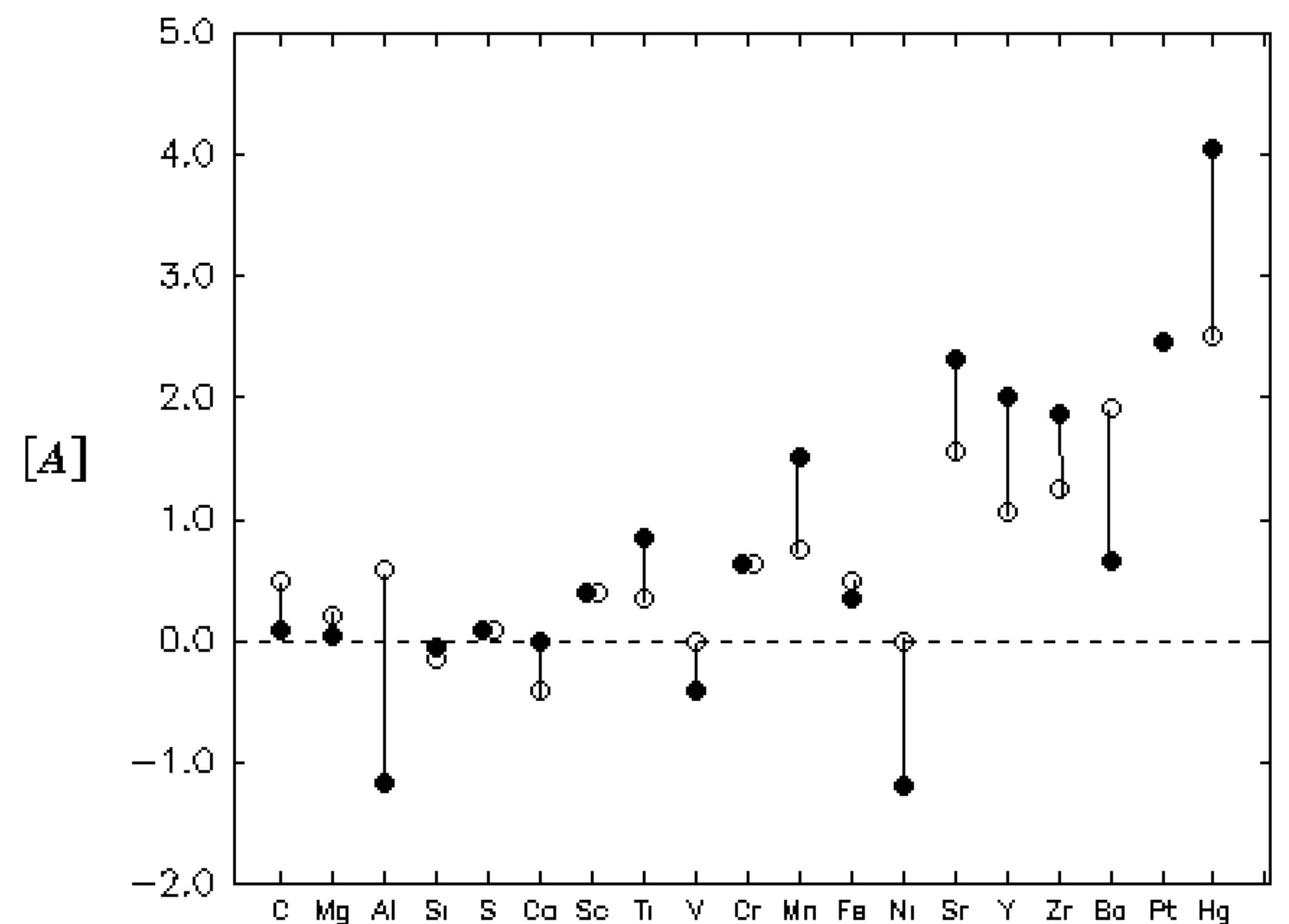


Fig. 1b. The same as in Fig. 2a but for AR Aur A and B (Khokhlova et al. 1995).

higher discrepancies of these elements than the former. Detailed investigation of other SB2 systems with approximately equal mass CP components is necessary in order to specify the time and origin of chemical anomalies appearance.

Acknowledgements. In conclusion we would like to acknowledge T.A. Ryabchikova and other authors of ARD study for the possibility of using their results and data before publication.

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HYDROGEN LINES IN B-e STARS ENVELOPES

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ABSTRACT. The investigation of Balmer $H\alpha$ and $H\beta$ line profiles for 28 Be and Be-shell stars have been carried out. The emission profiles of stars were obtained by subtracting from "A Be star atlas" photospheric line profiles which were computed from Kurucz models and corrected from gravity and rotation. The relationships between emission-line widths, equivalent widths and rotational velocity for 28 B-e stars confirm the origin of envelope these stars from rotational mass loss, consistent with a rotating, equatorial disk. The smaller emission disks shown the weak $H\alpha$ emission lines, the biggest – the strong one.

Key words: Be-stars, envelope, emissions lines, profiles

I. Introduction

Be-stars with emission hydrogen lines and luminosity classes III-V widely have been investigating during several decades. They represent about 20 percent of B stars. Studies of Be emission-line profiles permit to obtain the knowledge about the structure and dimensions of the stellar envelope. This paper includes the following distinction from early published work. We have taken all types of Be stars for our study from spectral type B2 to B8 including "shell stars" and "pole-on stars" on northern and southern hemispheres. The hydrogen absorption-line profiles from the underlying star were computed using Kurucz model atmospheres (Kurucz 1979) with correction of stars rotation and were subtracted from the observed Balmer emission lines. The aides of this paper is to describe and present the dynamical parameters of envelopes for wide class of Be stars.

II. Atmospheric models and processing

Be stars are distinguished from normal stars of the same spectral type by statistically greater values of the mass loss and by greater variability in the stellar wind. The amplitude of the variations is such that they cannot be interpreted as perturbations, and the conclusion is clear that the mass flux is highly variable in these stars. The strong variability of the mass flux could create a favorable condition for the formation of their cool envelope. The emission lines in Be stars exhibit a great variety of profiles. They most often exhibit a shallow, more or less central reversal. The intensity and width vary with time, but the emission intensity generally exhibits much greater variations than the line width. Emission profiles without a central reversal are also observed, as well as profiles with three emission peaks (Doazan, 1982). In spite of variability of these stars we find possible to determine the relationships between some parameters of stellar envelopes.

The 28 Be stars for this work have taken from "A Be star atlas" (Doazan et al., 1991). The Balmer lines $H\alpha$ and $H\beta$ were observed in the spectrum of each star by V.Doazan and collaborator at the Haute-Provence Observatory with CCD camera ISIS (resolution 0.18 Å and S/N=150). The list of stars is presented on table 1.

Effective temperature have taken from adopted parameters for our main-sequence models, (Slettebak et al., 1992); logarithms of gravity from dependents:

$$\lg g = 4 \lg T_{eff} + 0.4 M_{bol} + \lg(M/M_{\odot}) - 12.5$$

The observational profiles of hydrogen lines have been correct for the effects of photosphe-

ric absorption. The models of the photospheric Balmer line profiles for the rotating B star that lies in the middle of Be star envelope have been subtracted from observed profiles. The Balmer models permit to calculate the profiles of hydrogen lines for each models using effective temperature, gravity and metal abundance. The rotation of the star was corrected by Gray algorithm (1980). All the profiles were approximated with aid by cubic spline. For resulting profiles were determined emission-line width and equivalent width. An example of this procedure is shown on Figure 1 for $H\alpha$ line in the spectrum of the star HD 29866.

The Be "shell stars" have the central absorption component V-shaped, because the Be star disk projected against the stellar photosphere. Therefore we corrected these effect in a completely artificial way by extrapolating these Balmer emission profiles. The extrapolated profiles have no astrophysical basis.

The statistical character of work and results means, that each star was taken in the separate moment of time for all class of Be stars.

III. Conclusions

On the pictures 1-6 is shown the relationships between emission-line widths and rotational velocity, equivalent widths and rotational velocity, emission-line widths and equivalent widths. The values of emission-line widths (FWHM) plotted against rotational velocity ($v \sin i$) in Figures 2, 3. The both Balmer lines show a correlation that large emission widths correspond to large rotational velocities. These Figures means that Be stars shows a rapid rotation and forming a nebulous ring which gives an emission lines. Such correlation was first demonstrating by Struve (1931), than

other astronomers e.g. Slettebak et al. (1992). The emitting envelope has an axial symmetric, like Struve-model of Be stars.

The values of emission-line widths (FWHM) plotted against equivalent widths (EW) in Figures 4, 5. The stars with $v \sin i < 101$ km/s are designated by triangles, with $v \sin i > 101$ km/s by filled circles. The correlation permit to do the same conclusion concerning emitting envelope, but no conclusion that stronger emission lines are narrower from the star than the weaker lines.

The values of emission-line equivalent widths (EW) plotted against rotational velocity ($v \sin i$) in Figures 6,7. An absence of correlation for $H\alpha$ and a presence for $H\beta$ can point on inhomogeneous structure of envelope so as radiation in the $H\beta$ line origin in more deeper layers of the emitting disk, then in $H\alpha$ line.

Acknowledgment. One of the authors (S.N.) was supported by grant of American Astronomical Society.

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Table 1: List of stars

Star	Sp.class	$v \sin i$	T_{eff}	$\log g$
HD 6811 42 And	B6.5IIIe	80	13500	4.0
HD 25940 48 Per	B4Ve	200	17000	3.90
HD 29866 HR1500	B8IVne	300	11750	3.88
HD 32343 11 Cam	B3Ve	100	19000	3.92
HD 32991 105 Tau	B3Ve	200	19000	3.88
HD 37490 Ome Ori	B2IIIe	160	22400	3.92
HD 42054 HR2170	B5Ve	220	15500	3.91
HD 45995 HR 2370	B2IVe	250	22400	3.89
HD 54309 HR2690	B2IVe	200	22400	3.92
HD 56014 27 CMa	B3IIIepsh	150	19000	3.89
HD 56139 Ome CMa	B2.5Ve	80	20300	3.91
HD 58050 OT Gem	B2Ve	140	22400	3.92
HD 58343 HR 2825	B3Ve	< 40	19000	3.89
HD 58715 Bet CMi	B8Ve	245	11750	3.98
HD 67536 HR 3186	B2.5Vne	290	20300	3.91
HD 78764 HR 3642	B2IVe	120	22400	3.92
HD 89890 HR 4074	B3IIIep	70	19000	3.88
HD 93563 HR 4221	B8IIIesh	280	11750	3.98
HD100673 A Cen	B9Ve	125	10600	3.98
HD120991 HR 5223	B2IIIep	70	22400	3.92
HD124367 HR 5316	B4Ve	300	17000	3.90
HD127972 Eta Cen	B2IVe	350	22400	3.92
HD134481 Kap Lup	B9Ve	160	10600	3.98
HD157042 Iot Ara	B2.5IVe	320	20300	3.91
HD164284 66 Oph	B2IV-Ve	240	22400	3.92
HD167128 HR 6819	B3IIIe	50	19000	3.89
HD203467 6 Cep	B2.5Ve	150	20300	3.91
HD217891 Bet Psc	B5Ve	100	15500	3.91

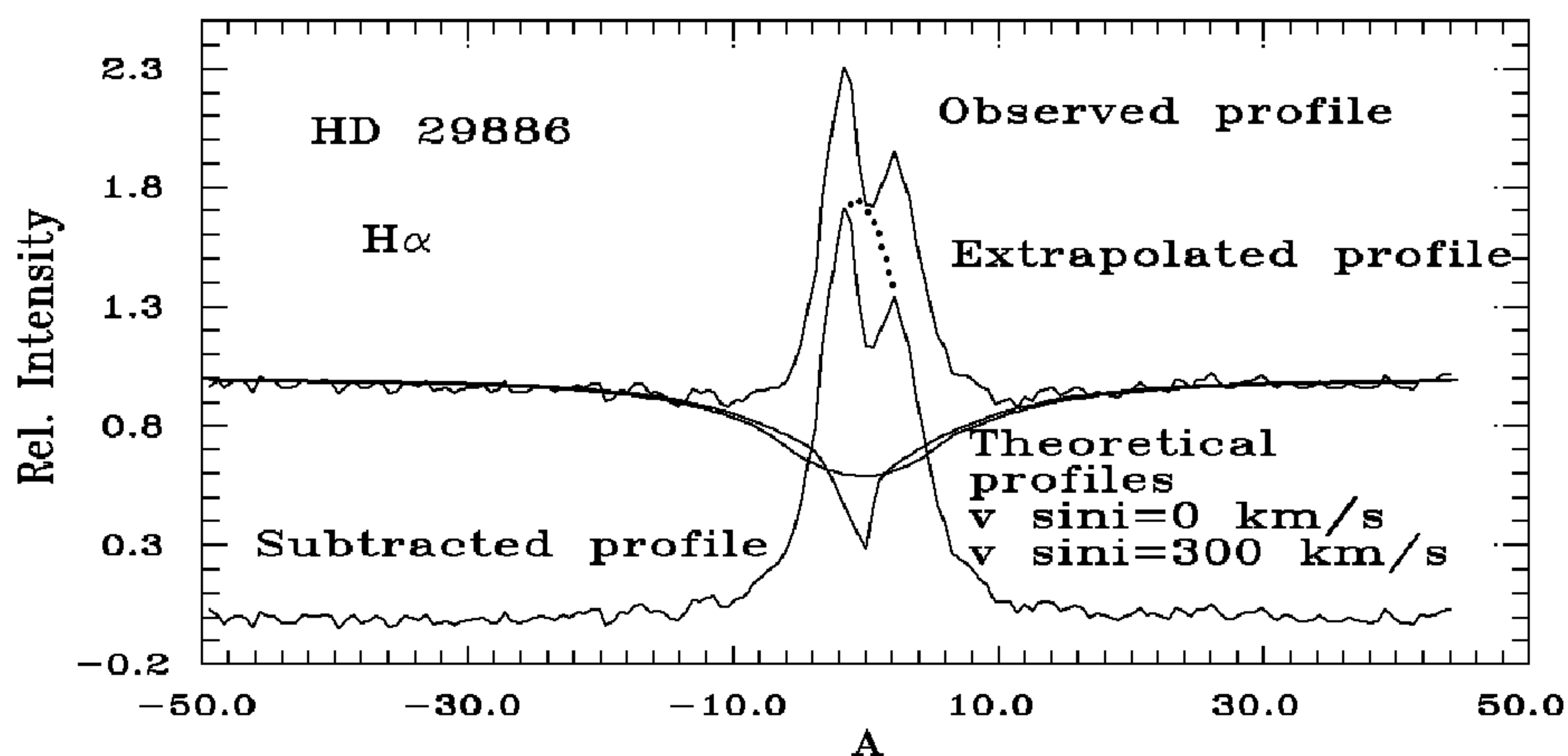


Figure 1. Example of the subtraction procedure for HD29866.

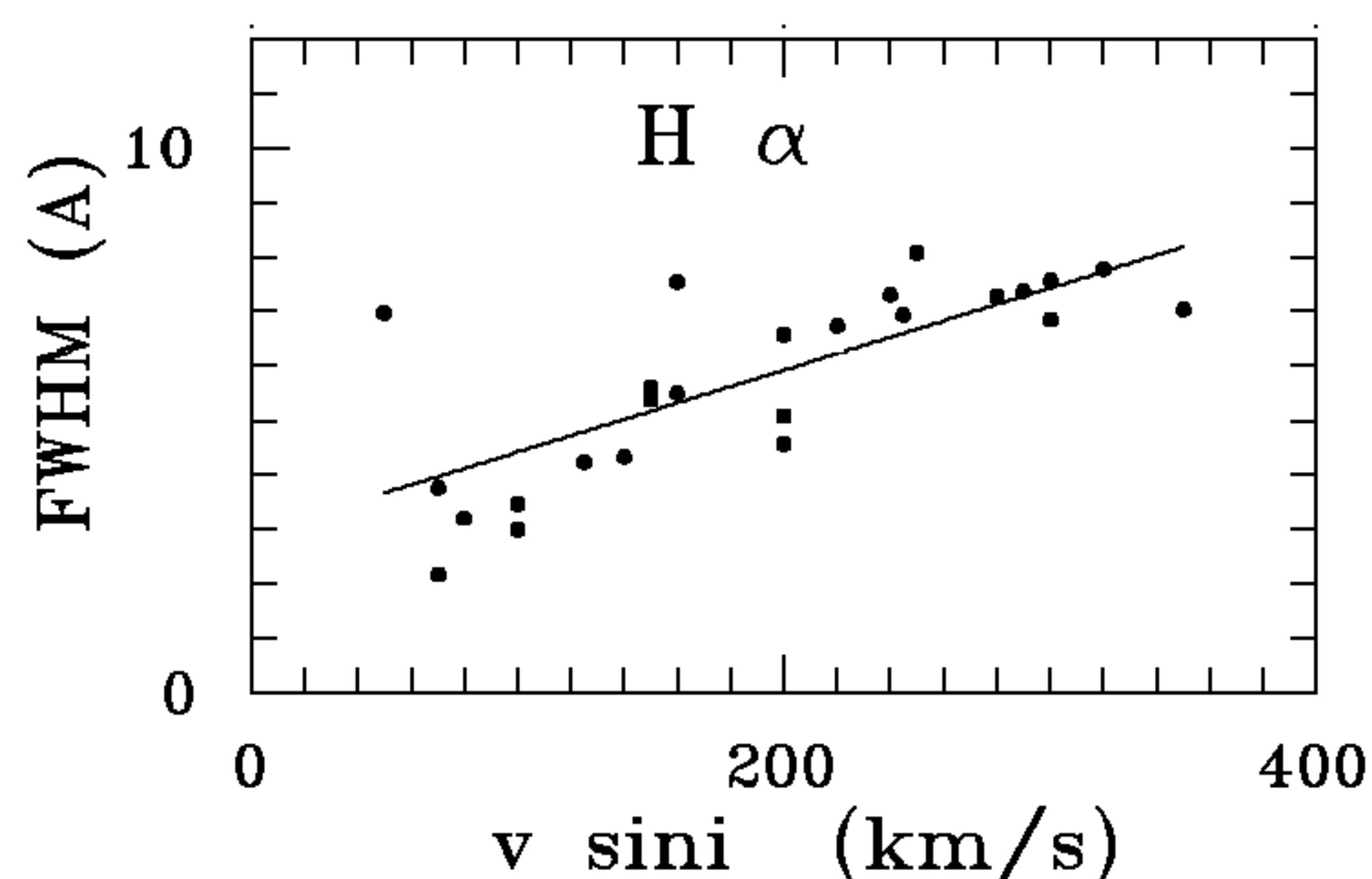


Figure 2. H α emission-line widths vs. $v \sin i$.
Correlation coefficient $r=0.72 \pm 0.14$

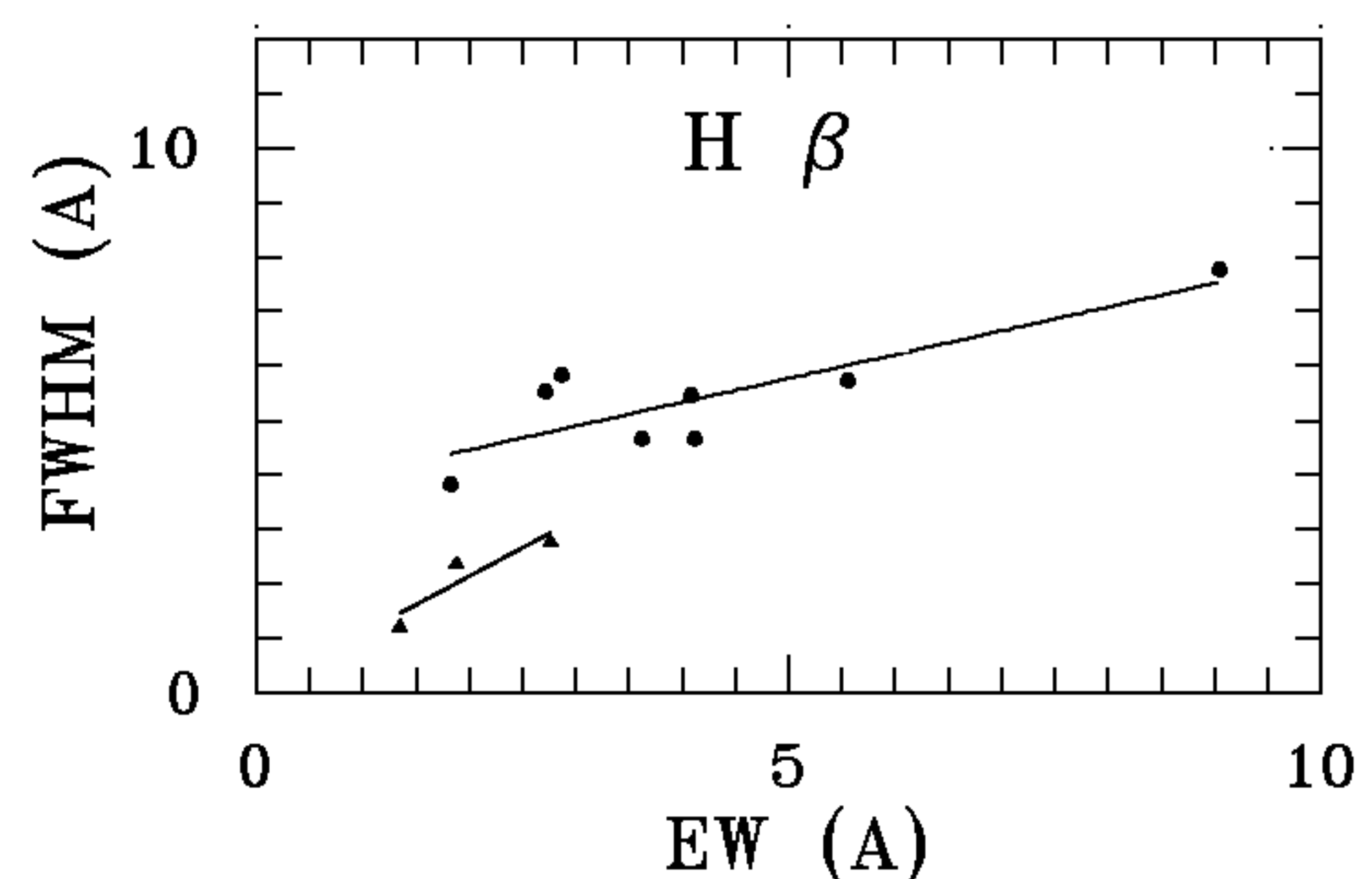


Figure 5. H β emission-line widths vs. equivalent widths. Stars with $v \sin i > 101$ km/s are designated by filled circles, and $v \sin i < 101$ km/s by filled triangles.

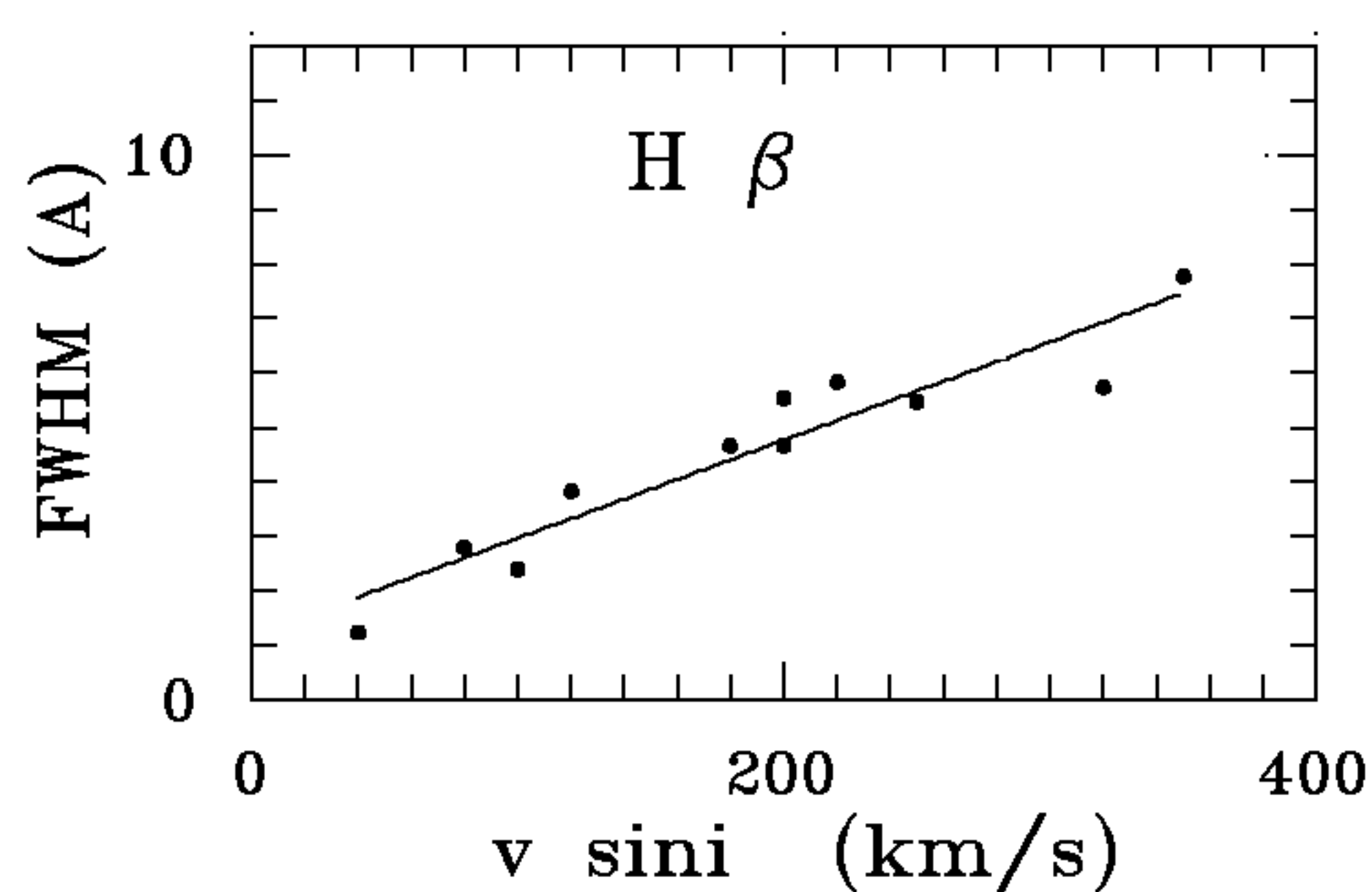


Figure 3. H β emission-line widths vs. $v \sin i$.
Correlation coefficient $r=0.86 \pm 0.17$

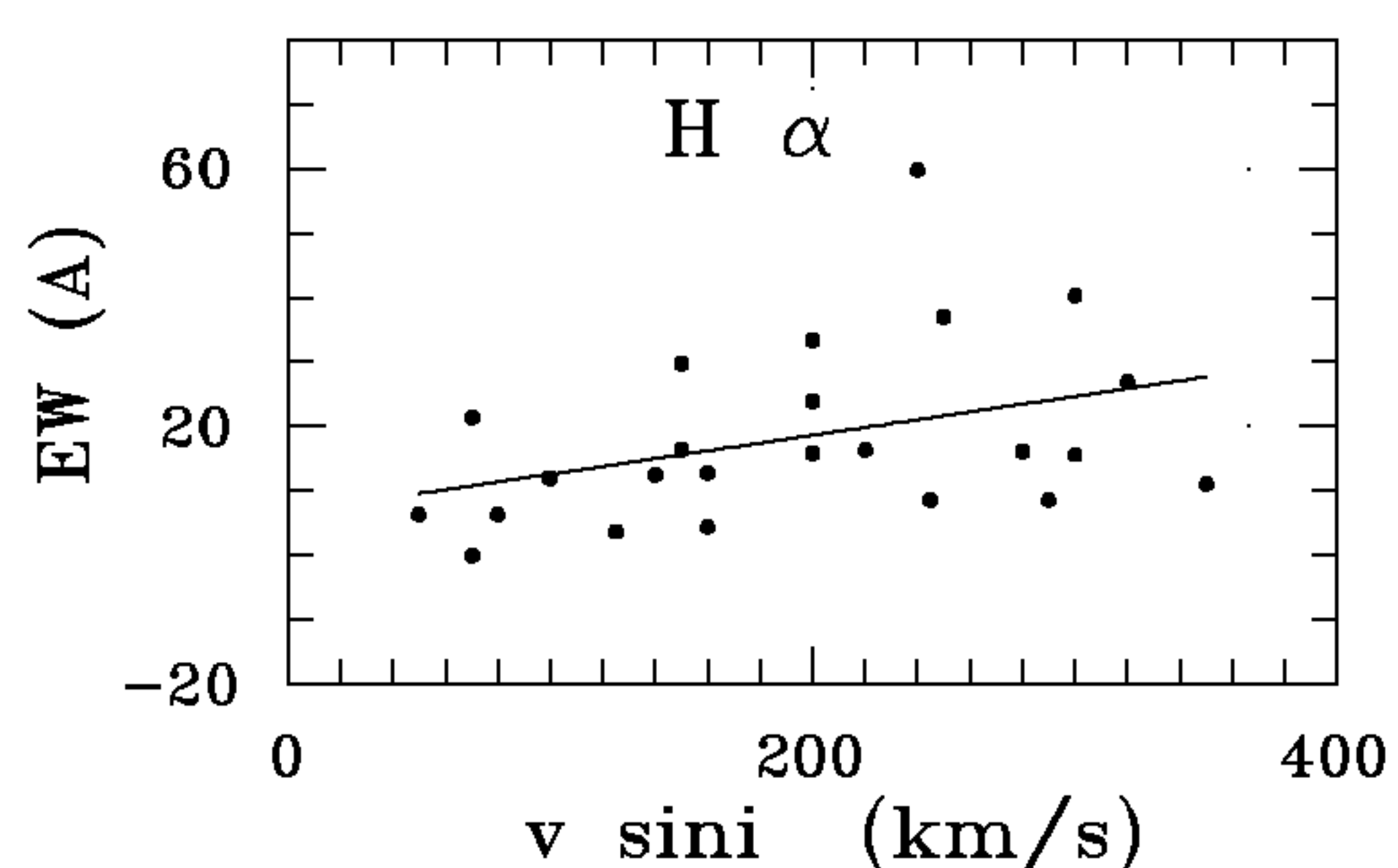


Figure 6. H α emission-line equivalent widths vs. $v \sin i$. Correlation coefficient $r=0.37 \pm 0.19$

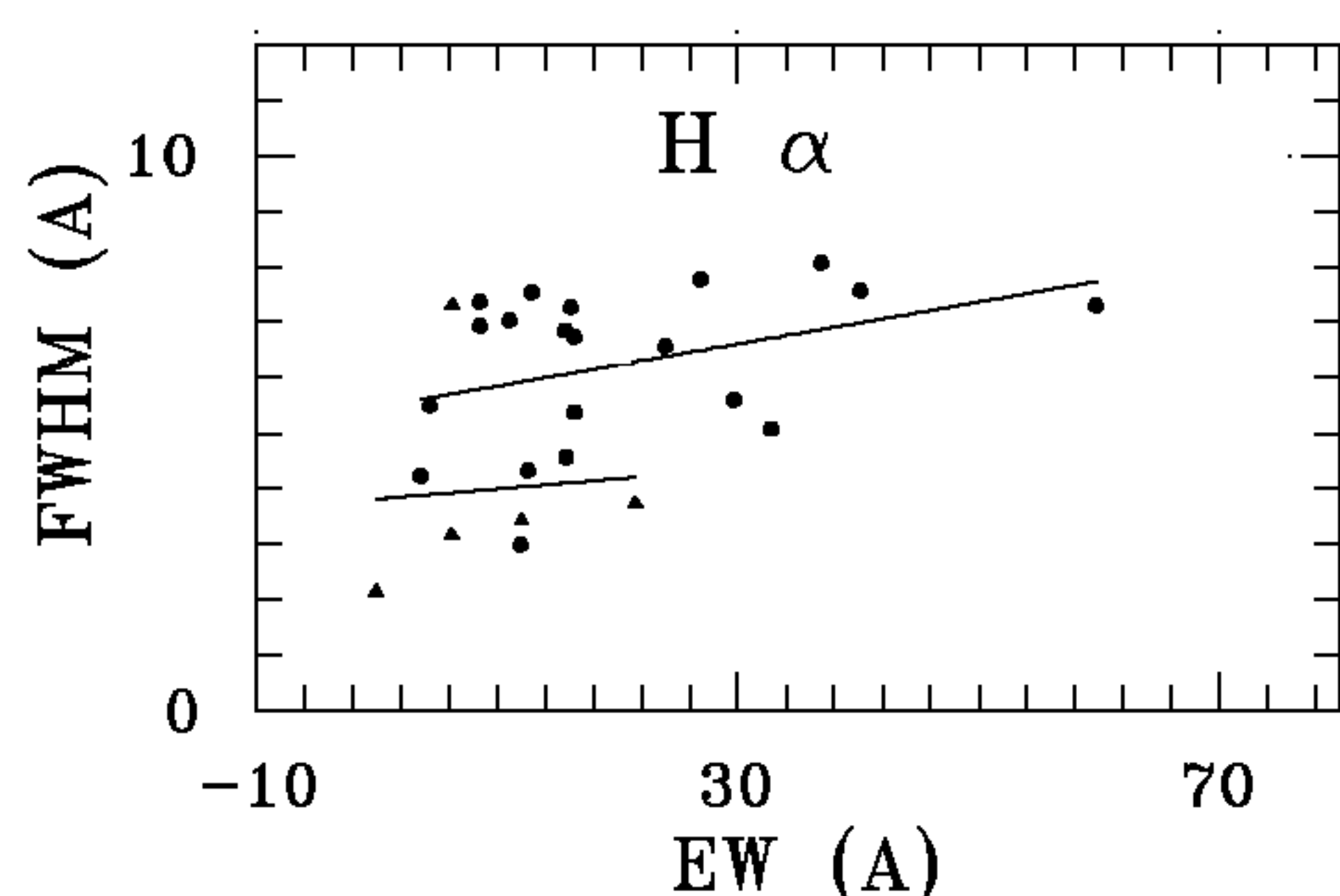


Figure 4. H α emission-line widths vs. equivalent widths. Stars with $v \sin i > 101$ km/s are designated by filled circles, and $v \sin i < 101$ km/s by filled triangles.

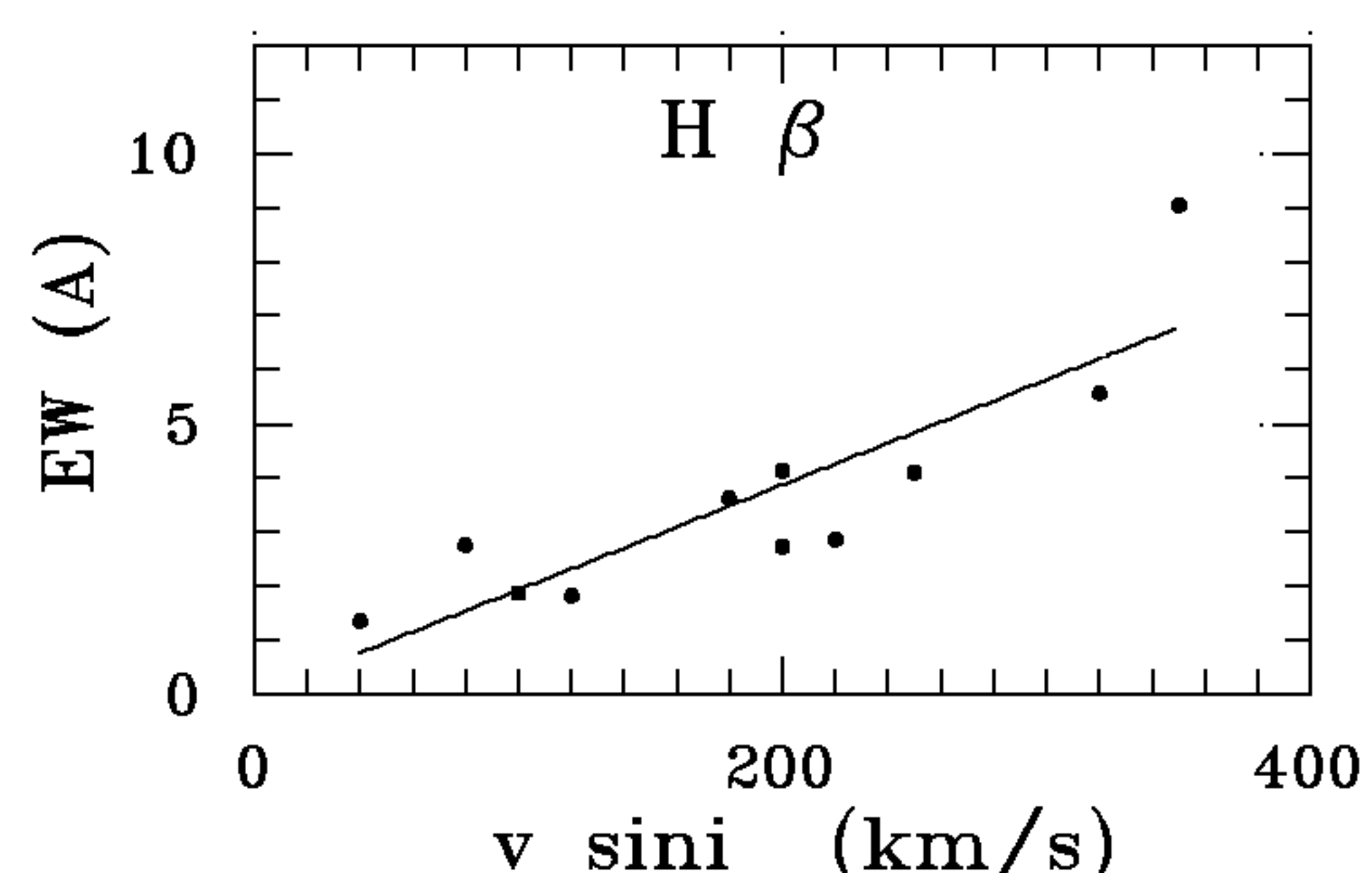


Figure 7. H β emission-line equivalent widths vs. $v \sin i$. Correlation coefficient $r=0.79 \pm 0.20$

NITROGEN ABUNDANCE FROM THE ULTRAVIOLET NH BANDS

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ABSTRACT. Data for NH bands region λ 336 nm from CD-ROM's N1 and N18 of Kurucz's database are tested and corrected using the spectrum of the Sun as a star. The nitrogen abundance indicators are selected for spectral resolutions $\delta_g = 0.0025$ nm and 0.02 nm. Using this indicators we derived $[N/Fe] = 0$ in atmosphere of K0 giant γ^1 Leo. The accuracy of nitrogen abundance estimations is considered.

Key words: cool stars, stellar atmospheres, CNO abundances, synthetic spectra

Introduction

The nitrogen abundance $A(N)$ in atmospheres of cool stars is usually obtained using spectra of nitrogen-contained molecules. Absorption lines of NH are the most preferable for this goal, because ones do not show a dependence on abundances of carbon and oxygen as well on the C/O ratio. Unfortunately NH bands lie in UV and IR spectral regions which are inconvenient for observations and complicated for theoretical modeling.

Modern databases for the stellar spectroscopy give new possibilities for the more realistic theoretical modeling of cool star spectra even for $\lambda < 450$ nm. If they are used for abundance determinations one must first select suitable spectral features (the indicators of the element abundance). We carried out the study of the nitrogen abundance indicators using Kurucz's data from CD-ROM's for NH bands region near λ 336 nm.

Procedure

We tested the data for region λ 336 nm using a comparison of computed synthetic

spectra (SS) with the observed spectrum the Sun as a star (Kurucz et al. 1984). Our SS were computed for solar model atmosphere (Kurucz 1995) with microturbulent velocity $V_t = 1$ km/s (Gurtovenko & Kostik 1989) using WITA2 (Pavlenko et al. 1995) and STARSP (Tsymbal 1994) programs. Abundances $A(C)=8.55$, $A(N)=7.97$, $A(O)=8.87$ and $A(Fe)=7.54$ were taken for computations. We adopted the dissociation potential $D_0(NH)=3.37$ eV. Atomic and molecular line lists were taken from the Kurucz's (1995) database (CD-ROM's N1 (file LOWLINES.DAT) and N18, respectively). Oscillator strengths of NH lines were reduced by factor 2 following Shavrina et al. (1996). Our analysis showed that the contribution of other molecules in the opacity may be ignored in λ 336 nm region.

LOWLINES.DAT list was created by Kurucz to realize the statistical treatment of the atomic lines opacity in stellar atmospheres. It contains together with molecular lists 58 millions measured as well theoretically computed lines. Calculated line parameters are often affected by serious errors. Therefore for SS computations in the region λ 336 nm we reduced a length of list LOWLINES.DAT using the well-known procedure of the *lines selection*. Then, using a comparison of SS's with Kurucz et al. (1984) atlas of the solar spectrum we excluded from LOWLINES.DAT ~ 100 lines with obviously wrong parameters. Afterwards the subset of LOWLINES.DAT list (~ 3000 lines) was corrected using VALD atomic lines list (Piskunov et al. 1996).

As was suggested by many authors (see Yakovina & Pavlenko 1997), there are unidentified opacity sources in UV part of cool star

spectra. To model their impact on the SS we implemented *an additional continuum absorption* using a parameter κ which enhances the continuum opacity by given factor. The best fit of the solar spectrum by SS in region $\lambda\lambda$ 334.6-337.5 nm was obtained for $\kappa = 1.9 \pm 0.1$.

Voigt profiles of absorption lines were computed for Kurucz's (1995) γ_2 , C_4 , C_6 damping constants. For atomic lines with unknown dumping constants and molecular lines these parameters were computed following WIDTH6 formulas (see also Pavlenko & Shavrina 1986). Van der Waals broadening in solar SS was computed with a correction factor $E = 1.5$ (Gurtovenko & Kostik, 1989) for all absorption lines.

For a comparison of observed and computed solar spectra we convolved our SS with a gaussian $\delta_g = 0.0025$ nm. To obtain conclusions for lower resolutions both observed and computed spectra were convolved also with $\delta_g = 0.02$ nm.

Results

NH spectrum in region λ 336 nm consists of bands with $\Delta v = 0$ of $A^3\Pi - X^3\Sigma^-$ and $c^1\Pi - a^1\Delta$ systems. The spectrum shape is formed mainly by (0-0) (near λ 336 nm) and (1-1) (near λ 337 nm) bands of A-X system. The fit of the observed solar spectrum by SS for resolution 0.02 nm and the nitrogen abundance indicators are shown in Fig.1. We marked also points used *to bound* computed and observed spectra and demonstrate the sensitivity of SS on A(N) value. Positions of nitrogen abundance indicators for resolutions 0.0025 nm and 0.02 nm are given in Table 1.

Using chosen indicators of A(N) we obtained $[N/Fe] = 0$ in atmosphere of metal-deficient ($[Fe/H] \sim -0.3$) K0-giant γ^1 Leo. We used the same data as Shavrina et al. (1996) and our subset of LOWLINES.DAT list. Note, new estimation $[N/Fe]$ exceeds one in Shavrina et al. (1996) only on 0.1 dex, but this result cancels a qualitative conclusion about the nitrogen deficit in the atmosphere of K-giant γ^1 Leo.

An influence of uncertainties of values $D_0(NH)$, T_{eff} , $lg g$, κ and abundances of any metals on nitrogen abundance in atmosphere of γ^1 Leo was studied in paper (Shavrina et

Table 1. UV nitrogen abundance indicators in the solar spectrum.

$\delta_g = 0.0025$ nm		$\delta_g = 0.02$ nm		
λ_{min}	r_{min}	λ_{min}	r_{min}	λ_{max}
334.733	0.80			334.63
335.805	0.38	335.850	0.38	
336.006	0.17	336.016	0.24	
336.060	0.28	336.074	0.37	
336.398	0.49			336.31
336.518	0.65			336.50
337.059	0.39	337.084	0.38	336.84
337.111	0.39	337.142	0.45	
337.171	0.39			

λ_{min} - positions of the nitrogen abundance indicators in nm;

r_{min} - residual intensities at λ_{min} , computed for solar A(N) ($\delta_g = 0.02$ nm);

λ_{max} - positions of the flux maximums which are sensitive to nitrogen abundancen in nm.

al. 1996). Authors concluded that the alone parameter $D_0(NH)$ can lead to serious uncertainty of A(N). In this work a dependence of our results on completeness of line list was considered. We found:

- the lack of large amount of weak absorption lines in SS can lead to the nitrogen abundance underestimation;
- the effect becomes more strong for lower spectral resolutions;
- for Sun and K0 giant γ^1 Leo effect is weak, namely $\Delta [N/H] \leq 0.1$ dex.

Taking into account all factors discussed above, we estimate the accuracy of our nitrogen abundance determination using UV bands of NH as $\Delta [N/H] \leq 0.2$ dex.

Acknowledgements Authors are thankful to Prof. R.L.Kurucz for kindly providing of CD-ROM database, Dr. V.V.Tsymbal for providing of the STARSP program and the authors of VALD for providing line lists.

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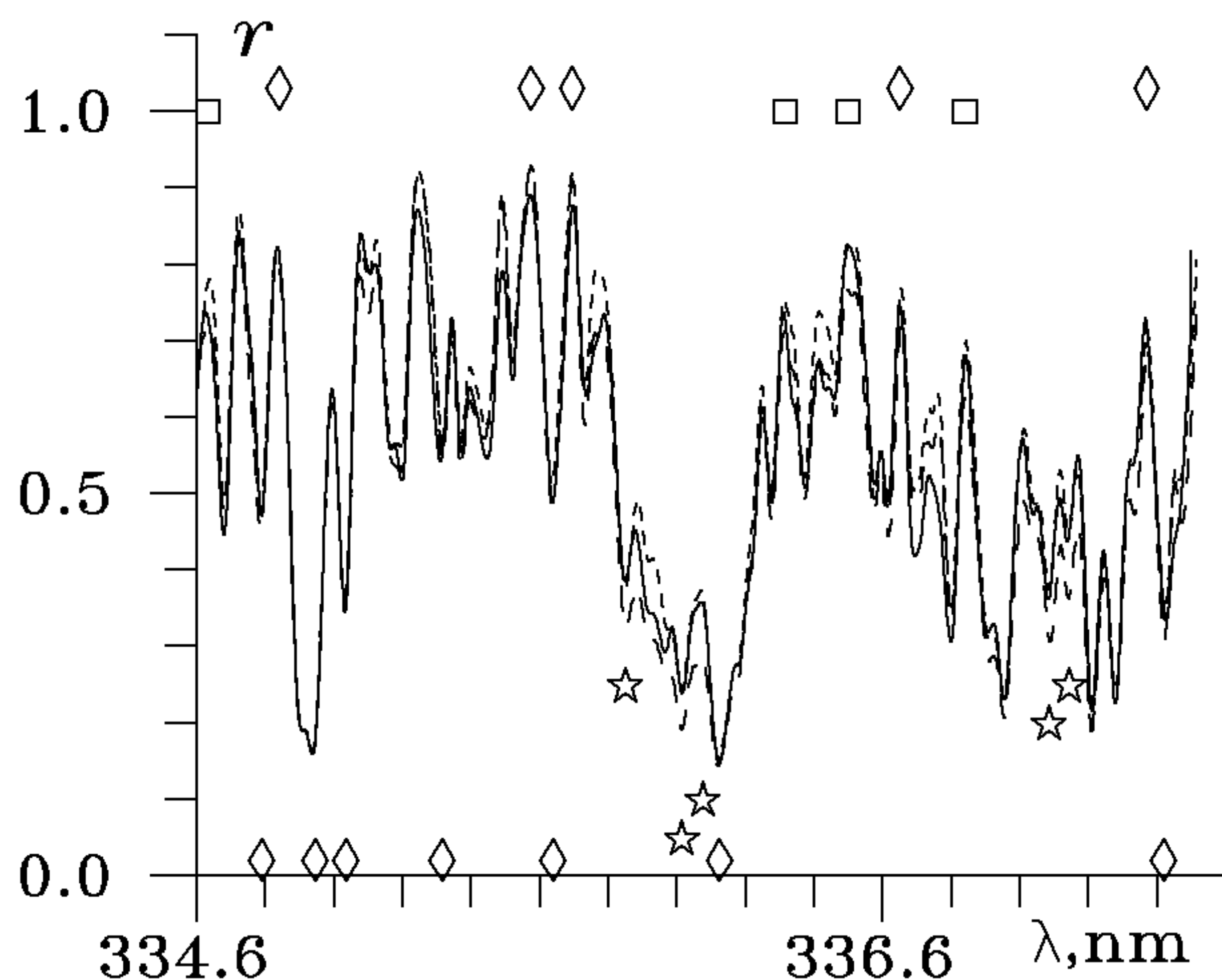


Figure 1. Observed (solid line) and synthetic (dashed lines) solar spectra in region λ 336 nm for resolution $\delta_g = 0.02$ nm. Short and long strokes are SS computed for $A(N) = 7.97$ and 8.27 , respectively. Diamonds, stars and squares mark wavelengths of the spectral details used to bond observed and synthetic spectra, the nitrogen abundance indicators and the sensitive on $A(N)$ flux maximums, respectively.

FREQUENCY ANALYSIS OF BIMODAL CEPHEIDS

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ABSTRACT. The Fourier analyses of photoelectric Berdnikov's (1992) V-observations of some of bimodal Cepheids (AS Cas, EW Sct, V 367 Sct, TU Cas and CO Aur) are performed. For stars with two known periods new identifications are carried out. EV Aql and S Sge are attributed to bimodal Cepheids and added to them. More detailed subdivision of bimodal Cepheids is suggested on the ground of their mode classification.

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

Frequency analyses of photoelectric Berdnikov's (1992a, 1992b, 1992c, 1992d, 1992e, 1992f) V-observations, received at the Mt. Maidanak Observatory, some of bimodal Cepheids (AS Cas, EW Sct, V 367 Sct, TU Cas and CO Aur) were performed. EV Aql and S Sge were attributed to bimodal Cepheids and added to them. The following results are obtained.

AS Cas: This star is known as bimodal Cepheid with the ratio of the secondary period to the main one $P_1/P_0=0.7127$ (Berdnikov, 1992g). $P_0=3.02467$ ($f_0=0.3306145$) and $P_1=2.15555$ ($f_1=0.4639187$). In the fourth edition of the General Catalogue of Variable Stars (Kholopov et al., hereafter GCVS, 1985a) close value of the main period $P_0=3.02125$ ($f_0=0.330989$) is given. Our analysis of 1988-1991 season's observations gives bigger (by 0.0027) values of these frequencies: $f_0=0.3333485$ and $f_1=0.4666516$, and their ratio of 0.7143. The respective amplitudes are equal to: $A_0=0.253$ and $A_1=0.133$ mag. Besides, two more frequencies with smaller amplitudes are found: $f_2=0.797269$ ($A_2=0.073$) and $f_3=1.1333678$ ($A_3=0.056$). The ratio of the secondary period to the main one is close to theoretical value 0.711, if the main period

is taken as P_{1H} , and the secondary - as P_s , instead of the main tone and the first overtone. This identification holds true also for 12 bimodal Cepheids from the above Berdnikov's work, except CO Aur, at which this ratio $P_1/P_0=0.8008$, that confirms a conclusion (Mantegazza, 1983) about its pulsations in the first and second overtones. The frequencies f_2 and f_3 are linear combinations of two main frequencies f_0 and f_1 : $f_2 = f_1 + f_0$ and $f_3 = 2f_0 + f_1$.

S Sge: According to GCVS (1987) the star is a spectral binary system (SB1) with an orbital period of 675 days. A main component is a Cepheid with a period of 8.382086 days ($f=0.119302$). Up to JD=2418000 the period was a little smaller: 8.381968 days ($f=0.119304$). From 146 observations we find the main frequency $f=0.119293$ ($A=0.323$) and three its harmonics $2f=0.238588$ ($A=0.070$), $3f=0.357907$ ($A=0.050$), $4f=0.477182$ ($A=0.035$). Besides, the frequency 1.006338 ($A=0.020$) is found. From multiple ratio we have identified it as $6f_s$ and the main frequency - as f_{1H} . It permits to attribute S Sge to the group of bimodal Cepheids similar to AS Cas.

EW Sct: The star is known as a bimodal Cepheid (Cuypers, 1985) with the main period $P_0=5.8195$ ($f_0=0.171836$), the secondary period $P_1=4.0646$ ($f_1=0.2460266$) and their ratio $P_1/P_0=0.6984$. Our analysis has confirmed these results with a little smaller values of frequencies $f_0=0.1717212$ ($A=0.176$) and $f_1=0.2458112$ ($A=0.120$). Their ratio coincides with the above $f_0/f_1=0.6986$. A fact of interest is a detection at this star another three frequencies - the first harmonic of the main frequency $2f_0=0.3434215$ ($A=0.024$) and linear combinations of two frequencies f_1

and f_0 : $f_1 + f_0 = 0.4175041$ ($A=0.033$) and $f_1 - f_0 = 0.0741082$ ($A=0.024$). Thus, this star as well as AS Cas is multimodal Cepheid similar to RR Lyr or delta Sct stars.

V367 Sct: According to GCVS (1987) this star is known as a bimodal Cepheid with the main period $P_0 = 6.29307$ ($f_0 = 0.1589049$), the period

of the first overtone $P_1 = 4.38466$ ($f_1 = 0.2280678$) and their ratio $P_1/P_0 = 0.696744$. The star is a member of the open cluster NGC 6649.

Our analysis has given close values of the frequencies and their ratio: $f_0 = 0.1589009$ ($A=0.174$) and $f_1 = 0.2280611$ ($A=0.119$), $f_0/f_1 = 0.696747$. Besides, similarly to the case of EW Sct, the first harmonics of these frequencies $2f_0 = 0.3177947$ ($A=0.028$) and $2f_1 = 0.4536010$ ($A=0.014$), as well as their linear combinations $f_1 + f_0 = 0.3869774$ ($A=0.018$) and $f_1 - f_0 = 0.0691491$ ($A=0.017$), are found.

TU Cas: It is known as a bimodal Cepheid. Hodson et al. (1979) give the following value for the ratio of the secondary period to the main one: $P_1/P_0 = 0.7097$, where $P_0 = 2.139298$ ($f_0 = 0.467443$) and $P_1 = 1.51830$ ($f_1 = 0.6586313$). It is noted, that the amplitude A_1 for 67 years has decreased from 0.4 V to 0.25 V. Asymmetry of the light curve M-m changes within the limits of 0.17-0.35 of the period value.

The frequency analysis has confirmed these results: $f_0 = 0.4674420$ ($A_0 = 0.289$), $f_1 = 0.6586474$ ($A_1 = 0.109$) and $f_0/f_1 = 0.7097$. Besides, we have also found other five frequencies: two harmonics of the main frequency $2f_0 = 0.9348839$ ($A=0.099$) and $3f_0 = 1.3996948$ ($A=0.036$), as well as three linear combinations of two main frequencies f_0 and f_1 : $f_1 + f_0 = 1.1260941$ ($A=0.072$), $f_1 - f_0 = 0.1912007$ ($A=0.038$) and $2f_0 + f_1 = 1.5909257$ ($A=0.047$).

CO Aur: This star is unique of all known bimodal Cepheids, which pulsate in the first and second overtones (Mantegazza, 1983): $P_{1H} = 1.7841$ ($f_{1H} = 0.5605066$), $P_{2H} = 1.4255$ ($f_{2H} = 0.7015082$) and $P_{2H}/P_{1H} = 0.799$, which is close to the theoretical value of 0.8. Our analysis has also picked out these main frequencies: $f_{1H} = 0.5608409$ ($A=0.175$) and $f_{2H} = 0.7025039$

($A=0.040$); their ratio $f_{1H}/f_{2H} = 0.798$. Frequencies

$2f_{1H} = 1.1138610$ ($A=0.036$), $2f_e = 1.0540236$ ($A=0.012$), $2f_g = 1.2644378$ ($A=0.011$) and $f_{3H} = 0.8450646$ ($A=0.010$) are found too. Thus, it is possible to name this Cepheid as a multimodal one.

EV Aql: In GCVS (1985a) it is noted, that its period is variable, and are resulted its values up to JD2423900 $P = 38.67$ days ($f = 0.02586$) and after the date $P = 38.767$ days ($f = 0.02580$). Our determinations have confirmed this frequency: $f_0 = 0.0258636$ ($A=0.324$). Three its harmonics are found too: $2f_0 = 0.0517686$ ($A=0.112$), $3f_0 = 0.0775896$ ($A=0.041$) and $4f_0 = 0.1034960$ ($A=0.022$). However, the third (from amplitude) in a power spectrum is the frequency $f_1 = 0.0227485$ ($A=0.047$), the ratio of which to the main frequency $f_1/f_0 = 0.880$. It is close to the theoretical value of the ratio - the frequency of the second overtone to the frequency f_s : $f_{2H}/f_s = 0.889$.

It can be summarized, that the most characteristic frequencies of bimodal Cepheids are f_{1H} and f_s , one of which (more frequently f_{1H}) acts the part of the main frequency.

At CO Aur in a role of the main frequency is f_{1H} , the secondary one is the frequency f_{2H} , and f_s is absent. There are first harmonics of the frequencies f_e and f_g introduced by the author earlier (Bezdeneshnyi, 1994a, 1994b) for RR Lyr and δ Sct stars. CO Aur is the most interesting case among multimodal Cepheids.

However, at EV Aql the main frequency is f_s (f_{1H} is away), and the secondary one is f_{2H} . Probably, at EW Sct and V367 Sct the main frequency is f_s , instead of f_{1H} . Then, the second frequency will be the harmonic of f_{1H} : $f_1 = 2f_{1H}$, and the ratio of frequencies f_0/f_1 of these stars equal respectively to 0.699 and 0.697 will be closer to the theoretical value $f_s/2f_{1H} = 0.703$.

This more detailed subdivision of bimodal Cepheids, pulsating in the frequencies f_{1H} and f_s , into two subgroups follows from Berdnikov's data (1992g) for 13 bimodal Cepheids too. The average ratios of periods P_1/P_0 for two samples are equal to 0.703 and 0.711.

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FREQUENCY ANALYSIS OF DELTA SCUTI VARIABLE STARS.I.

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ABSTRACT. The Fourier analyses are performed for photoelectric observations of two δ Scuti stars V567 Oph and KU Cen. It is shown that V567 Oph is a multiperiodic star and KU Cen has one main period.

Key words: Stars: δ Scuti, RR Lyrae, Fourier analysis.

V567 Oph. Two independent observational sets (189 V-measurements) of the star (Poretti et al., 1990) have been analysed by the frequency analysis method. The first set (49 observations for two nights at a time interval of 4 days) was received on Pic-du Midi one-meter telescope in 1984, the second one (the more extensive set) is obtained on 0.91-m reflector at Serra La Nave (Catania) for two consecutive nights two years later. The authors of the above article have confirmed, that the period offered by de Bruyn (1972) equal to 0.149 days holds true, instead of 0.130 days, Hoffmeister' (1943) period, who has discovered the star and classified it as RR_c Lyrae type. They give elements of the star, derived on the basis of all photoelectric maxima:

$$Max_{hel} = J.D.2445911.4396 + 0.1495218E. \quad (1)$$

As a result of our analysis it was found, that the first set is too short and does not suit at all. The biggest amplitude is at frequency 8.682, instead of the main frequency $f_0=6.6879879$, which gives smaller amplitude and much more greater remains. Therefore, the second set of observations (two consecutive nights) were analysed. The accounting of the main frequency $f_0=6.6881135$ with the amplitude $A=0.173$ mag and its two harmonics $2f_0=13.3760455$ ($A=0.039$) and $3f_0=20.07039$

($A=0.005$) has revealed the second main frequency $f_1=11.8416729$ ($A=0.009$). The relation f_1/f_0 is equal to 1.77, that permits to identify the frequencies f_1 and f_0 as double frequency of the first overtone and the frequency $f_g=1.5f_F$ introduced earlier by us (Bezdenzhnyi, 1995) at the analysis of RR Lyrae star AE Boo. If at AE Boo the main frequency is f_{1H} , at V567 Oph it is the frequency f_g . Two observational sets give bigger amplitude of the second harmonic of this $3f_g$ frequency ($A=0.008$) and the frequency $1/2f_{1H}=2.9394139$ ($A=0.014$). Thus, V567 Oph is a multimodal δ Scuti star.

KU Cen. This star is also analysed by us on the basis of 148 standard B-observations (Poretti et al., 1990), obtained at 1.07-m ESO telescope (La Silla) for two consecutive nights. A standard deviation of one observation is 0.005 mag. These authors have specified, that for the description of such an asymmetric light curve the main frequency f_0 and four its harmonics is required. Their accounting does not give any more significant frequency.

Our analysis has confirmed these results with that only by an insignificant difference, that the fifth harmonic ($6f_0$) is as significant as the fourth one - their amplitudes are 0.006 mag. The amplitude of $7f_0$ is considerably (4 times) less.

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FREQUENCY ANALYSIS OF DELTA SCUTI VARIABLE STARS. II.

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ABSTRACT. The Fourier analyses performed for photoelectric observations of two delta Scuti stars V1162 Ori and AV Cet show that these stars are multiperiodic with most significant frequencies identified as radial mode overtones and their linear combinations.

Key words: Stars: δ Scuti, RR Lyrae types, Fourier analysis.

I. V 1162 Ori (BD -7° 1108).

The star was discovered by P. Lampens (1985) at the research of Am stars. Then it was observed by T. Poretti et al. (1990). For seven nights 324 B-observations were obtained at the observatory Merato. These authors specify obvious presence of main frequency $f_1=12.71$ c/d and its harmonic $2f_1$. After they had been subtracted the power spectrum showed rather a complex structure about a centre with the frequency $f_2=11.28$ c/d. In taking account of this frequency gives no appreciable improvement of the root-mean-square remains. The deviations of individual curves from synthetic ones were considered to be rather random than systematic, and a conclusion was drawn that the star has a monoperiodic nature.

The author has recalculated these observations. Main frequency and two its significant harmonics were taken into account: $f_0=12.709$ (A=0.126 mag), $2f_0=25.418$ (A=0.015) and $3f_0=38.127$ (A=0.007). After their subtraction some more frequencies were identified: $1.5f_0=19.062$ (A=0.008) and $f_1=11.278$ (A=0.007). Other frequencies are present too, but their amplitudes are less than a standard deviation of one observation (0.005).

Thus, this delta Sct type star is multiperiodic. In addition to the main frequency, identified as the frequency $f_g=1.5$ fundamental one introduced by us earlier (Bezdeneshnyi, 1994), and two its harmonics $2f_g$ and $3f_g$ (as well as $1.5f_g$), there is one more frequency of the first overtone $f_{1H}=f_1$ as well as, probably, the harmonic of fundamental frequency $6f_F=50.832$ (A=0.005). Taking into account all this, it is clear, why the remains after the subtraction $f_0=f_g$ and $2f_0=2f_g$ were not reduced to one period ($P_1=P_{1H}$).

II. AV Cet (=HR401=44 Cet).

AV Cet was found as a short-periodic variable star of δ Sct type by Jorgensen et al. (1971). They have determined the amplitude of its light curve variations about 0.2 mag and approximate period of 0.07 days. Then the star was observed at 0.84-m Mexico telescope by Gonzalez-Bedolla et al. (1990) in V-system during four nights for 6 days' interval. 221 observations of the star were obtained with the average time between successive ones about 6 minutes. The authors of the above work have confirmed the light variation of AV Cet as δ Sct type star. They have done Fourier analysis of the observations and have found the main frequency $f_1=14.5930$ (P=0.0685), i.e. have confirmed and specified the uncertain period, given by their predecessors. After subtracting this frequency from the given observation data they have found the second frequency $f_2=19.1862$ ($P_2=0.0521$). The pulsational constants $Q_1=0.032$ and $Q_2=0.024$ have been calculated for the main period in a fundamental mode and for the first overtone, respectively.

Their ratio $Q_2/Q_1=0.75$, is close to that of two periods: $P_2/P_1=0.76$.

The author has analysed these observations too, and the following frequencies have been found: $f_F=14.598$ ($A=0.0045$), $f_{1H}=19.184$ ($A=0.0024$), the third frequency $f_g=1.5f_F=21.883$ ($A=0.0015$) being main at V1162 Ori. The ratio of fundamental frequency to the first overtone frequency $f_F/f_{1H}=0.761$. Besides, two more frequencies are found: probably, nonradial mode $f_{nr}=14.878$ ($A=0.0028$) and its multiple frequency $1/6f_{nr}=2.452$ ($A=0.0018$). The ratio of nonradial frequency to the fundamental one $f_{nr}/f_F=1.020$ coincides with that for the first two frequencies from five found for the $\theta 2$ Tau star (Breger et al., 1989): $f_2/f_1=1.019$.

Thus, AV Cet is a multiperiodic δ Sct type variable star.

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MULTIPERIODICITY OF RR LYRAE STARS. T SEXTANTIS.

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ABSTRACT. The Fourier analyses performed for 401 photoelectric V-magnitudes of the RR_c Lyrae variable T Sex (Barnes III et al.) show that the star may be multiperiodic with most significant frequency f_{1H} , frequencies multiple to that of f_{1H} as well as to frequencies f_g and f_s introduced by us.

Key words: Stars: RR Lyrae type, Fourier analysis, mode identifications

Earlier the author (Bezdenzhnyi, 1994) performed the analysis of periods of RR_c Lyr type star AE Bootis and showed, that it is a multiperiodic star. Fourteen frequencies have been found, the most important of which are: f_{1H} , f_0 , f_{2H} , $f_g=3/2f_0$ and $f_e=5/4f_0$. Other frequencies are expressed as linear combinations of the main ones.

In the present work a star of RR_c type T Sex is also investigated by the frequency analysis of 401 V-measurements (Barnes III et al., 1988) for five nights at 13 days' interval. The star was investigated photometrically by many authors. We have used elements present for different intervals JD and constructed a period variation graph: a wave is seen with the cycle $\Pi=24000$ days (about 66 years) and with an amplitude of period variation $\Delta P=0.00006$ days. Probably, it is due to the orbital motion because of star's binarity. At the analysis a period 0.324698 days from the fourth edition of the General Catalogue of Variable Stars (1987) is accepted as a period of the first overtone P_{1H} characteristic of the RR_c stars.

At the account of one frequency the biggest peak is at the frequency $f=3.079955$ ($P=0.32468$) with the amplitude $=0.180$. For

taking account of asymmetry of the light curve the main frequency f_{1H} and its four harmonics were considered: $f_{1H}=3.0797$ ($A=0.219$), $2f_{1H}=6.1509$ ($A=0.023$), $3f_{1H}=9.2390$ ($A=0.018$), $4f_{1H}=12.3128$ ($A=0.012$) and $5f_{1H}=15.3931$ ($A=0.006$). Then four more frequencies were found: two multiple ones to f_g frequency introduced earlier $8f_g=9f_{1H}=12f_0=27.6775$ ($A=0.004$) and $13f_g=45.042$ ($A=0.003$), as well as multiple to new frequency introduced in this work $f_s=1.5f_e$. The latter is related to the frequency f_e introduced earlier, like f_g is related to the fundamental frequency f_0 . The frequency f_s is also present in Cepheids and is as characteristic of them as the frequency f_{1H} - of RR_c stars (see in the same volume). Thus, two frequencies multiple to the frequency f_s are found: $3f_s=12.9882$ ($A=0.005$) and $15f_s=65.222$ ($A=0.003$). T Sex, as well as AE Boo, is a multiperiodic variable star.

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ON CLASSICAL CEPHEIDS' PERIODS.

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ABSTRACT. The Fourier analyses performed for photoelectric Berdnikov's (1992) V-observations of seven classical Cepheids give periods (frequencies) and amplitudes their oscillations as well as their harmonics (from one to six for different stars).

Key words: Stars: Cepheids, Fourier analysis

Frequency analysis of photoelectric Berdnikov's (1992 a, 1992 b, 1992 c, 1992 d, 1992 e, 1992 f) V-observations, obtained at the Mt. Maidanak Observatory, some of classical Cepheids (U Aql, EV Aql, CE Cas, CF Cas, DL Cas, Z Lac, CI Per, S Sge and SV Vul) were performed. EV Aql and S Sge were attributed to bimodal Cepheids (therefore these are considered in another work, see in this volume), for other stars the following results are received.

CE Cas: It is known in the fourth edition of the General Catalogue of Variable Stars (Kholopov et al., hereafter *GCVS*, 1985a) as a visual-binary ($2''.4$) star, both A and B components of which are Cepheids with periods: $P_A=5.1410583$ ($f_A=0.1945124$) and $P_B=4.4793014$ ($f_B=0.223249$). CEA Cas is a possible member of the cluster NGC 7790.

The frequency analysis has reliably shown these frequencies and double ones to them: $f_A=0.1945163$ ($A=0.133mag$), $f_B=0.2232491$ ($A=0.143$), $2f_A=0.3890433$ ($A=0.055$) and $2f_B=0.4465072$ ($A=0.047$).

CF Cas: According to *GCVS* (1985a) the star is a possible member of the cluster NGC 7790, period $P=4.87522$ ($f=0.2051189$). In the power spectrum this frequency and two more of its harmonics are found: $f=0.2051244$ ($A=0.240$), $2f=0.4102539$ ($A=0.082$), $3f=0.6180549$ ($A=0.027$).

CI Per: According to *GCVS* (1987) the form of a light curve and period are variable ($P=3.35-3.40$). Frequency analysis has given a little smaller value of the period $P=3.297$ ($f=0.3033$) with amplitude $A=0.233$ as well as two of its harmonics $2f=0.6093$ ($A=0.061$) and $3f=0.9099$ ($A=0.026$). The frequency $4f=1.221$ with the amplitude $=0.014$ is seen uncertainly.

SV Vul: In *GCVS* (1987) the period $P=45.0121$ ($f=0.0222162$) and its linear change with an epoch are given: -0.0001814 . Our value of secular decrease of a period gives a factor not less than 0.00023 . Frequency analysis has given, according to it, a little bigger value of frequency of the main oscillation $f=0.0222302$ ($P=44.984255$) with amplitude $A=0.441$. Its five harmonics were also found: $2f=0.044465$ ($A=0.191$), $3f=0.066710$ ($A=0.098$), $4f=0.088953$ ($A=0.055$), $5f=0.113852$ ($A=0.026$), $6f=0.133486$ ($A=0.016$). Besides these, there is an unidentified frequency $f_1=0.001825$ ($A=0.020$) in the power spectrum, which corresponds to a period of 548 days (1.50 years).

U Aql: In *GCVS* (1985a) the value of the period $P=7.02393$ ($f=0.1423704$) is given and its variability is informed. The frequency analysis has revealed the main frequency $f=0.1423600$ with an amplitude $A=0.325$ and four its harmonics: $2f=0.2847470$ ($A=0.112$), $3f=0.4270484$ ($A=0.050$), $7f=0.9978584$ ($A=0.022$) and $5f=0.71185$ ($A=0.011$).

DL Cas: In *GCVS* (1985a) the star is noted to be a member of the cluster NGC 129, $P=8.000669$ ($f=0.1249895$). Frequency analysis has confirmed the above period: $f=0.1249895$ ($A=0.253$). Three harmonics of this frequency are also found: $2f=0.2499848$ ($A=0.070$), $3f=0.3723370$ ($A=0.023$) and

$4f=0.4998956$ ($A=0.010$).

Z Lac: Progressive change of a period with epoch is noticed in *GCVS* (1985b), the elements contain the square-law member with a factor -3.4×10^{-8} , $P=10.885613$ ($f=0.0918643$).

Our analysis, except specified frequency, has revealed six more of its harmonics: $f=0.0918621$ ($A=0.375$), $2f=0.1837106$ ($A=0.046$), $3f=0.2756523$ ($A=0.055$), $4f=0.3676261$ ($A=0.043$), $5f=0.4569291$ ($A=0.034$), $6f=0.546379$ ($A=0.021$) and $7f=0.6355304$ ($A=0.018$). $M - m = 43$ for this star is more than for other ones.

Thus, for seven classical Cepheids periods (frequencies) and amplitudes of their oscillations as well as their harmonics (from one up to six) are determined. For SV Vul a factor of secular change of a period is specified.

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RADIATIVE TRANSFER EFFECTS ON THE COLORS OF RR LYRAE STARS

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ABSTRACT. The methods of Davis and Cox (1980), are applied to a series of models described by Bono and Stellingwerf(1994) to determine the colors of RR Lyrae stars. Convection is ignored and the radiation flow is treated by a complete variable Eddington, multi-frequency dependent radiative transfer approximation.

Key words: Stars: RR Lyr-type; radiation transfer

1. Introduction

The application of the method of variable Eddington multi-group radiative transfer to the problem of colors of pulsating stars was started in Art Cox's group (J-15) in 1965. We initially addressed the question for cepheids in lieu of the "bump" mass discrepancy problem (Davis, 1971). As determined, the effects of a multi-frequency dependent radiative transfer calculation(mfirt), on the light curves of Cepheids is small. (Keller and Mutchlecner, 1971). The "bump" mass discrepancy problem was resolved by new opacities that include more detailed line calculations (Moskalik, Buchler and Maron 1992). Believing that effects from the mfirt approximation are more important, as compared to the usual equilirbiun diffusion approximation, as we go to higher luminosity to mass pulsating stars, we decided to study a model of W. Virginis, first proposed by Christy (1966). The effects of mfirt, over Christy's diffusion model, was to cause a standstill in the light curve that more closely agreed with the observations, (Davis, 1972 and 1974). This model also showed alternations in the minimum and maximum of the velocity curve which is an indication of period doubling and then an

extension towards chaos(Buchler and Kovacs 1987). The process is observed in RV Tauri stars (Tsesevich, 1975). In 1972, working with Art Cox, we decided to apply these techniques to the question of the appropriate color average for pulsating stars, The result was that the $\langle B \rangle - \langle V \rangle$ average is the most appropriate for cepheids (Cox and Davis, 1975) and RR Lyrae (Davis and Cox, 1980) stars. In this paper we discuss further application of our mfirt approximations to obtain colors for a series of models proposed by Bono and Stellingwerf (1994). As expected the effects on the luminosity's is to increase the flux over the diffusion flux and therefore result in an increase color temperature for these RR Lyrae models of from 2 to 300 K. This increase more closely agrees with the star's steady state temperature.

In section II we briefly describe the hydrodynamic models and in section III the mfirt results. A discussion of the resulting colors and conclusions is given in section IV.

2. Hydrodynamic models

To conserve computer time we run the initial phase of the models using a non-equilibrium diffusion form of the radiative transfer until near limiting amplitudes are obtained. The hydrodynamic models are standard with quadratic pseudo-viscosity (4) and a simple cutoff (0.001). The opacities are KingIA tables from Los Alamos. The models are initiated using an LNA code and 100 zones with 10 zones in the optically thin region of the atmosphere and initial fundamental driving amplitude of 10 Km/s at the surface. We studied most of the models included in BS. From the linear analysis of the

BS model 3.40 we found a fundamental period, $P_0 = 0.532$, compared to a $P_0 = 0.527$ from BS (table 3).

3. Multi-frequency radiative transfer (mfrt) results for selected models

Do to space limitations we limit our discussion here to a general results only, leaving the details to a paper to be presented elsewhere. The hydrodynamic models (secII) are restarted using a multi-frequency set of opacities. In this case we used 13 groups located over the expected Planck distribution and with attention to selected edges, the Balmer edge for instance. Runs continued with the Gray opacities, and for the set of model parameters; Luminosities ($\log(L/L_\odot) = 1.81, 1.72, 1.61, 1.51$) and effective temperatures ($6000K < T_{eff} < 7500K$) as defined in BS, for comparison to the multi-frequency runs. General conclusions on colors will be given in section IV. The morphology of our light curves, grey and mfrt, for a model at $L=1.51$ and $T_{eff} = 6800K$ agrees fairly well the result in BS (fig.16). The light curve has a sharp spike before light maximum. Bono defines this model as a possible double mode pulsator. One major difference in the comparison of our models to those in BS, is not only the effect of convection, but in the amplitude of the velocity excusion. Our limiting amplitudes are considerably lower and the effect is undoubtalby due to the treatment of pseudo-viscosity.

4. Colors and Conclusions

The $\langle B \rangle - \langle V \rangle$ colors as estimated in the manner described in DC are closer to the correct static T_{eff} values using mfrt than for diffusion, i.e. approximately 300K closer. For a model at 7000 K and $\log(L/L_\odot) = 1.72$ we get $\langle B \rangle - \langle V \rangle = 0.22$ and a $T_{eff} = 6850K$.

Bono, Caputo and Stellingwerf (1997) find a $\langle B \rangle - \langle V \rangle = 0.231$ in general agreement with ours (table 19). Our slope in luminosity ($\log(L/L_\odot)$) versus $\langle B \rangle - \langle V \rangle$, at $T_{eff} = 7000K$, is steeper than theirs which in their case is almost constant at 0.23. From these results it still appears necessary to calculate the mfrt atmosphere if one is interested in obtaining the correct colors. As far as locating the appropriate velocity in the atmopshere a line transfer calculation of the mfrt atmopshere versus phase may be the preferred procedure at present. An adaptive mesh may not be that necessary an could infact, as an implicit scheme, smooth out observables such as "bumps" or "dips".

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DISCOVERY OF RAPID OSCILLATIONS IN Ap STAR HD 99563

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ABSTRACT. The observations of roAp stars at the Mt. Dushak-Erekdag station of Odessa Astronomical Observatory (Central Asia) have been carried out since 1992. In 1994 the searches for a new roAp stars were initiated. There were investigated 5 stars - candidates: HD15257, HD17317, HD99563, HD115606, HD217401. Their photometric features are presented. The Fourier spectra of 4 stars did not show variability in the high frequency region. The Fourier spectrum of HD99563 revealed the oscillations with a period of about 11.2 min. and amplitude 3.98 mmag. Evidently HD99563 is a new discovered roAp star.

Key words: Stars: Chemically peculiar - stars: Oscillations - stars: Variables: other

Rapidly oscillating Ap stars discovered by Don Kurtz in 1978 (Kurtz, 1990), are remarkable by low-amplitudes pulsations with periods from 5 to 20 min. These peculiar stars with line strength anomalies of Sr, Cr, Eu (may be one or two of these elements) possess strong magnetic fields. The objects are very important for asteroseismology: some of them have a rich set of pulsations, other pulsate with a single frequency.

Nearly all of 28 investigated up to now roAp stars were discovered in SAAO, by the Kurtz and Martinez group (see Kurtz, 1990; Martinez et al., 1993; Martinez & Kurtz, 1994a, 1994b). Although about 200 stars were examined for discovering especially northern roAp stars: Matthews & Wehlau (1985), Heller & Kramer (1988), Nelson & Kreidl (1993) - only two stars with positive declination are known. The most part of the objects is in southern hemisphere.

The search for the new roAp stars in the

northern hemisphere is very important. Firstly, a number of southern and northern roAp stars should be balanced. Secondly, it is necessary to extend the sample for more accurate definition of its astrophysical features. Thirdly, null results extend the sample of noAp (non-oscillating) stars, that is essential for the understanding of evolutionary processes, which distinguish oscillating Ap stars from the reliable stable Ap stars (see, for example, Mathys et al., 1996).

The test observations of well-studied HR1217 (HD24712) (Dorokhov et al., 1994b) showed that sky seeing of the Mt. Dushak-Erekdag is suitable for roAp star researches. The successful participation in the multisite γ Equ campaign 1992 organised by T. Kreidl and M. Nelson jointly with European Southern, Lowell, South African and Perth Observatories (Martinez et al., 1996) encouraged us to continue the roAp observations.

Since 1994 we started a survey for rapidly oscillating Ap stars at the Mt. Dushak-Erekdag observational station. Martinez, Kurtz and Kauffmann (1991) presented the detail searching scheme. They worked out the photometrical indicator for roAp stars based on the Strömgren colours. The method turned out to be very fruitful: approximately one from ten investigated stars was discovered as roAp star (Martinez & Kurtz, 1994). These photometrical criteria were used for extracting the list of candidates from uvby, beta Catalogue (Hauck & Mermilliod, 1990) the obtained list was verified with Catalogue Ap and Am stars (Renson, 1991) and the stars with SrCrEu peculiarities were saved. When remained numbers of stars were verified with the records of roAp and noAp stars by Martinez & Kurtz (1994), we re-

Table 1.

Star	b-y	m ₁	c ₁	β	$\alpha(1900)$	$\delta(1900)$	m _v	Sp	Sp (Rn)
HD15257	+0.178	+0.211	+0.780	2.762	2 22.3	+29 14	5.38	F0	
HD17317	+0.230	+0.226	+0.779	2.750	2 41.7	+20 56	8.3	A5p	
HD99563	+0.171	+0.206	+0.745	2.830	11 22.2	- 8 19	8.17	F0	F0 Sr
HD115606	+0.166	+0.297	+0.623	2.841	13 13.1	+13 31	8.3	A2	A2 Sr
HD217401	+0.187	+0.264	+0.717	2.737	22 55.3	+13 29	8.0	A2p	A2 Sr

vealed that approximately 30% of our candidates were presented in there. That is we picked the right way.

The observations were episodic, because the Mt.Dushak-Erekdag station is located in 3 thousands kilometers from Odessa, and we visited the station for participation in international programs or multisite campaigns. During 4 years we were able to observe 5 stars of the candidates' list. All the observations were carried out with the dual-channel photometer (Dorokhov & Dorokhova, 1994) mounted on 0.8 m Ritchey-Chretien telescope.

SPE package by Sergeev (1992) was adapted for a data reducing and filtering. We used a rectangle filter for the data smoothing and low-frequency Butterworth's filter for excluding trends.

The programs PERIOD by Breger (1990) and FOUR by Andronov (1994) were used for the frequency analysis.

Comparison star in the second channel of the photometer was observed if the suitable star occurred in the field of view. Even if the data of comparison star were not directly used for the light curve of investigated star (large differences of magnitudes or of spectral types), the second channel data were adapted for estimate of the sky transparency behavior in the high frequency region.

Table 1 lists HD numbers, Strömgren indices, positions (epoch 1900.0), magnitudes, spectral types from HD Catalogue and spectral types from Catalogue by Renson (1991) for all observed stars.

Table 2 is a Journal of observations: HD number, date, were used or no comparison star data, observational interval in hour, mean deviation for high-frequency region of the re-

arch star in mmag, the filter. The Fourier spectra of 4 stars which did not show the variability in the frequency region 50 - 400 c/d are presented in Fig 1 and 2.

The HD number of the star is shown above the panel and the Julian Date, the duration of the observations (in hours) and the number of 20-s integrations are listed in the upper right corner of the panel (following to Martinez & Kurtz, 1994b).

HD 17317 with comparison star were observed only 1.1 h on a poor photometrical night and the noise level was up to 12 mmag. After normalizing by the comparison star data the noise level decreased to 5 mmag and the absence of high frequency oscillations in this star is rather plausible (Fig.2). A low-frequency component of the data was filtered by Butterworth's filter (2 degree and 8% cutoff frequency).

HD 99563 was observed on the night 12/13 May of 1997 during 2 hour.

The data were acquired as continuous 10 sec integrations, the comparison star ($\alpha(1900)=11^h22^m50^s$, $\delta(1900)=-08^\circ28'.5$) was observed simultaneously in channel 2. Low-frequency trends of the data were removed with using Butterworth's filter (2 degree and 4% cutoff frequency). Fourier spectrum of

Table 2.

Star	Date	C	ΔT	σ	Flt
HD15257	22.11.1995		6.0	0.9	B
HD17317	01.11.1995	c	1.1	6.5	B
HD99563D	12.05.1997	c	2.0	1.6	B
HD115606	13.04.1997		4.0	1.1	B
HD217401D	13.09.1994	c	3.8	1.4	v Str
	10.10.1994	c	3.4	1.2	v Str

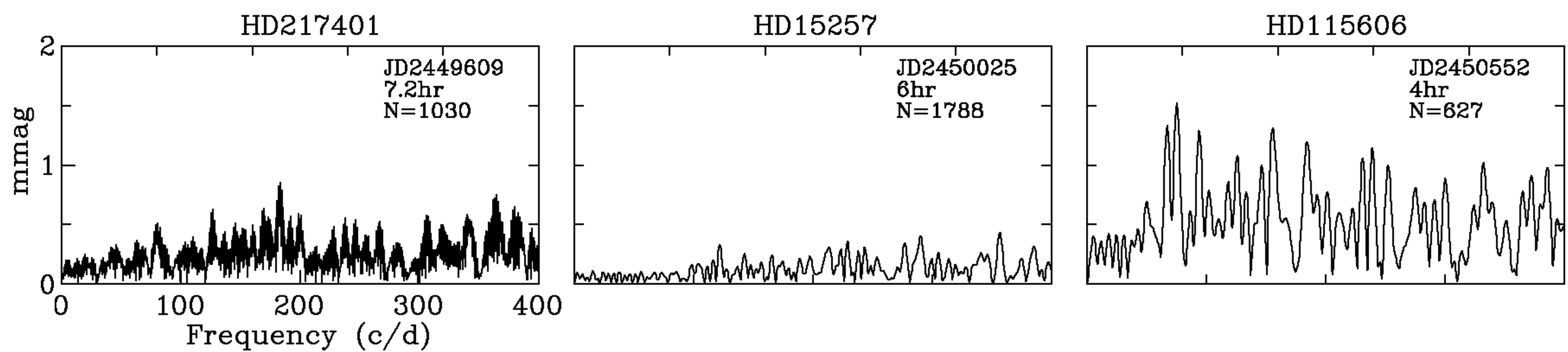


Figure 1: The null result of searches for high-frequency pulsation in Ap stars. Fourier spectra of 3 stars.

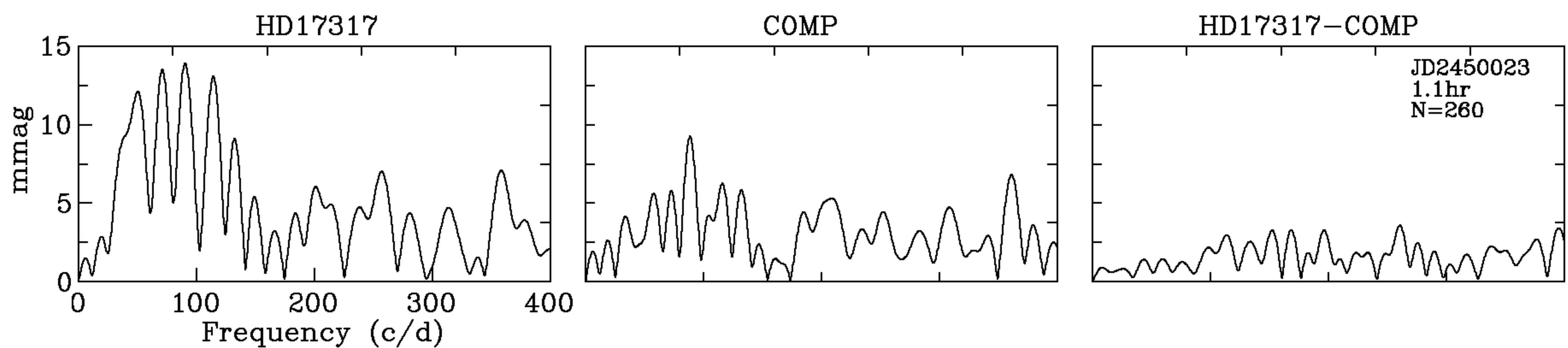


Figure 2: Fourier spectra of HD17317 (left) and comparison star (center) in the poor photometrical night. On the right panel - Fourier spectrum of differences

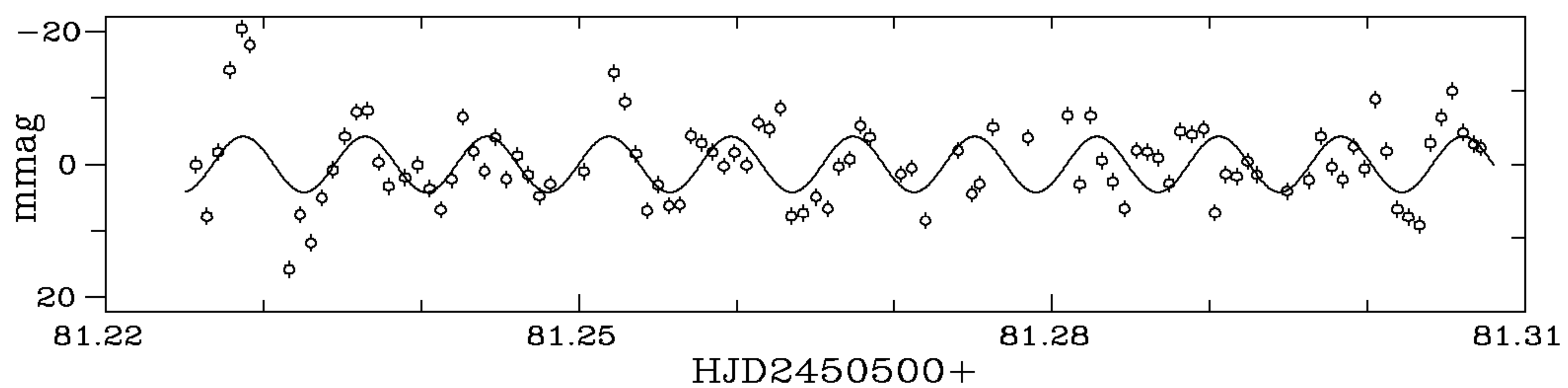
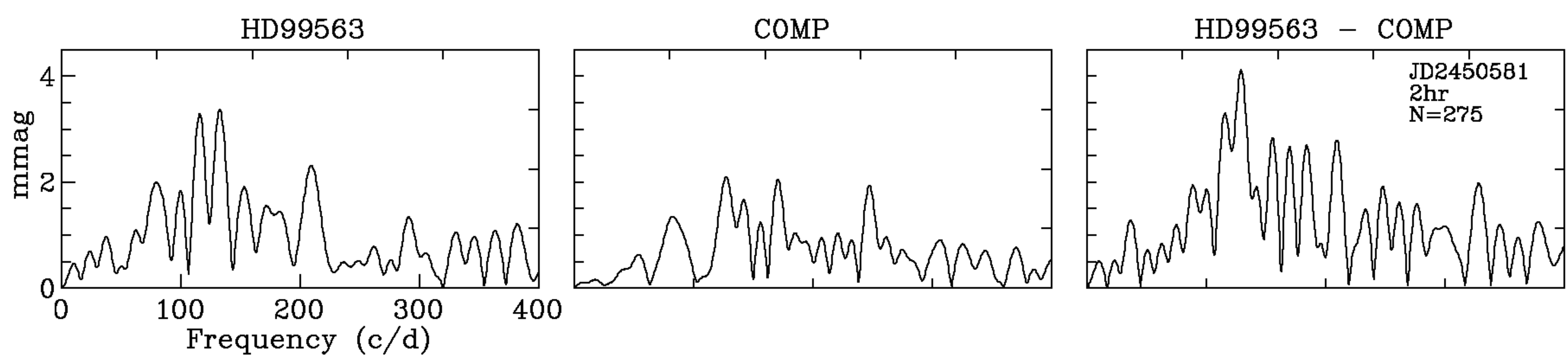


Figure 3: (Top) Fourier spectra of HD99563 (left), comparison star (center) and Fourier spectrum of differences (right panel). (Bottom) The light curve of HD99563 with the best-fit sinusoid of the period 11.2 min.

HD99563 revealed the peak at the frequency 127.6 c/d (top left panel in Fig.3). Normalizing by the comparison star data yielded the more prominent peak (top right panel in Fig.3) at frequency $f=128.9\pm0.635$ c/d (period 11.2 min and semi-amplitude 3.978 ± 0.38 mmag).

A bottom panel in Fig.3 shows 2 hour's light curve of the star with the best-fit sinusoid of the period 11.2 min.

Evidently a new roAp star is discovered, but the results of the work may be considered only as preliminary. We share the cautions made by Martinez & Kurtz (1994b), that roAp stars must be observed under the best atmospheric conditions and the observations have to be continued until the repeated reliable results are achieved. However this work was done without any financial support, "thanks to enthusiasm", and we had to use the "scraps" of observational time which was unworkable for base program stars.

Acknowledgments. I thanks Dorokhov N.I. for participation and assistance during observations and for comments to the work.

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PHOTOMETRY OF LOW AMPLITUDES δ SCUTI TYPE STAR VW ARI

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ABSTRACT. 48 hours of VW Ari observations during 11 nights in October 1993 were analyzed. The data were obtained with the dual-channel photometer at the Mt. Dushak-Erekdag (Central Asia) during multisite campaign of STEPPI network. Frequency solution derived from Mt. Dushak-Erekdag data was compared with the solution from STEPPI data. The conclusion was made about the necessity of inside calibration system with using of an artificial source. The suggestion that VW Ari belongs to λ Booti group of stars was considered.

Key words: Stars: δ Scuti: oscillations - star: Individual: HD 15165, BDS1269A, VW Ari - Techniques: photometric

VW Ari (HD 15165) is a primary component of binary system BDS 1269. A feature of the system is that its primary component has strong metal-deficient chemical composition whereas the secondary component is normal F type star. For the first time this fact was discussed by Mechler (1974) and recent investigations Andrievsky et al. (1995) confirm it. The existing of such an unusual system is an enigma, the history of BDS 1269A investigations is intriguing, too.

Mechler suspected the low amplitudes variability of the star, which was confirmed by Seeds & Horan (1976) and McMillan et al. (1976). Further Rucinsky (1978) and Persy (1980) revealed two periods using a very poor data. The frequency pattern was similar to δ Scuti type star, but Rucinsky (1978) assumed that VW Ari might be SX Phe (or RRs) type star because of its extreme metal-deficiency. Kurtz

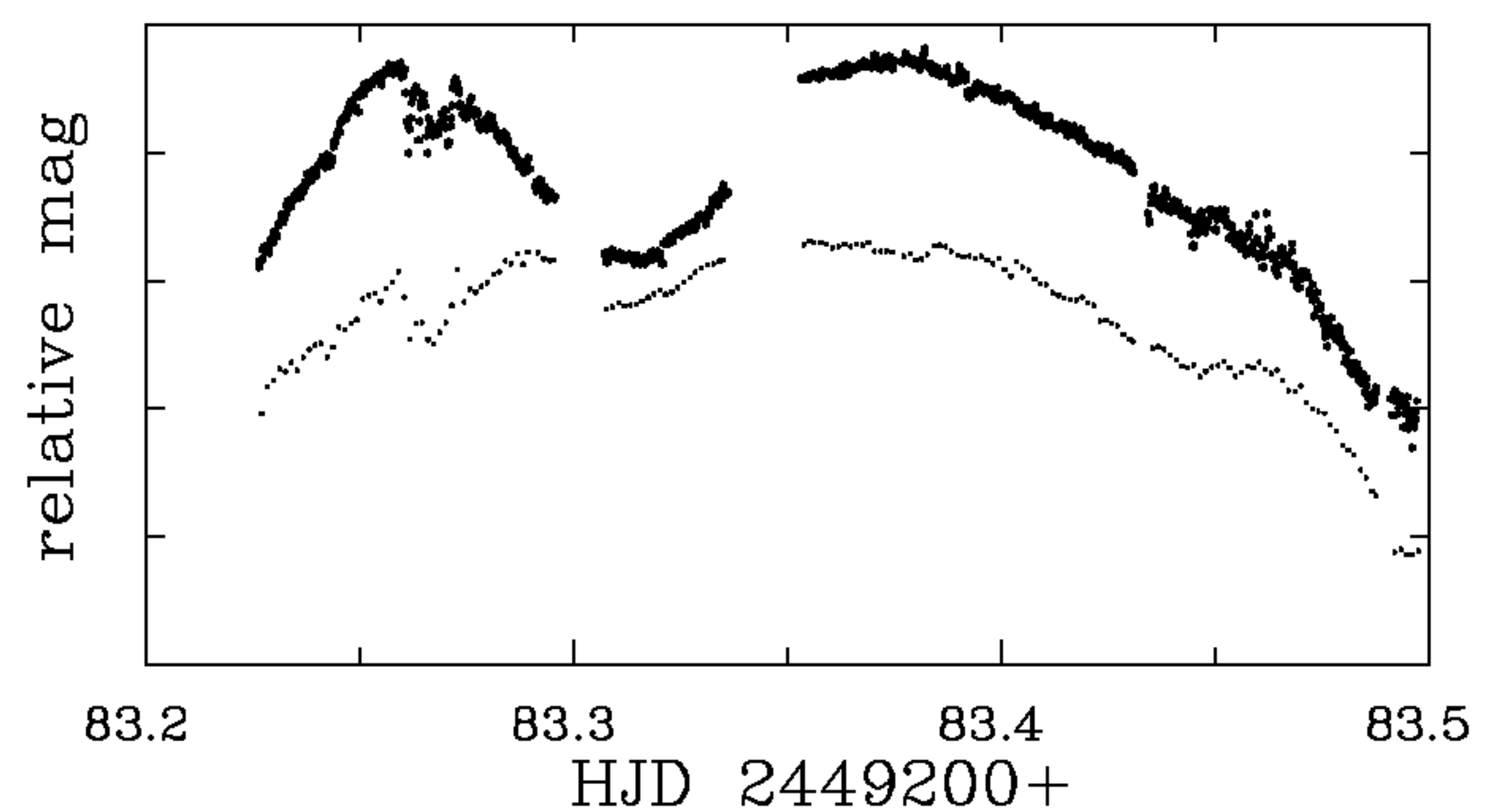


Figure 1: Typical instrumental light curve of VW Ari (upper) and comparison star HD 15095 (lower) obtained on 22 Oct. 1993 in dual channel mode. The intervals in light curves were used for channel calibrations. $0^m.9$ is added to data of comparison star for viewing convenience. A value of the point at magnitudes' axis is $0^m.01$.

(1980) put forward that metallicity of the star may be normal.

McNamara & Horan (1984) obtained measurement on BDS 1269A on 17 nights during time interval of 6 months. But they did not reveal strong component at 10.74 c/d, and supposed the redistribution of power into alternative modes.

A decade later Li & Jiang (1993) analyzing their own observations and reanalyzing the data of Persy and Rucinski obtained the very elegant 5 frequencies' solution. They noted the constancy of the frequencies' distribution between 1976 and 1987 years, but admitted the possibility of amplitudes' variation.

In 1993 the star was observed by STEPPI network (Liu et al, 1996, hereafter STEPPI93). STEPPI (STellar PHotometer

Table 1.

Date	JD 2449200+	ΔT (hrs)
08.10	69.	4.0
09.10	70.	5.0
11.10	72.	3.6
12.10	73.	3.6
13.10	74.	4.2
16.10	77.	4.6
19.10	80.	3.4
20.10	81.	2.6
21.10	82.	6.4
22.10	83.	6.4
23.10	84.	4.5

International) network was provided by three identical four-channel photometers allocated in three observatories: Xinglong observatory (China), Medon (France) and Observatorio del Teide (Spain) for program of δ Scuti stars' observations (see Michel et al, 1992). WET (Whole Earth Telescope) technique was applied for such multichannel observations (see Nather et al., 1990). In VW Ari campaign 1993 two observatories participated, Xinglong and Teide. The Mt. Dushak-Erekdag station of Odessa Astronomical Observatory (Central Asia, Dorokhov et al., 1994) with 0.8m Ritchey-Chretien telescope is just located in longitude "gap" between these. Participation in multisite δ Scuti campaign was by the first trial of such observations for our dual-channel photometer (Dorokhov & Dorokhova, 1994).

We obtained 48 hours of VW Ari observations during 11 nights of October 1993 in the same manner as STEPPI observations. The data comprise continuous 10 sec. or 20 sec. integrations through v Strömgren filter in both channels simultaneously. A comparison star HD15095 was observed in the second channel.

The data were corrected for coincidence counting losses, the sky background contribution was subtracted. Then these were transformed to instrumental magnitudes and corrected for the atmospheric extinction. The example of such dual-channel observations is shown in Fig.1. The data have been binned to 2 min. in-

tegrations by taking 12 points' averages. The time is given for the middle of interval. A mean square error is $0^m.001$ of a single observation for variable and comparison stars.

Table 1 gives a journal of the observation listing the civil date, Julian date for that night, observational interval in hours.

Channel calibrations (the observations of the comparison star through the primary channel and the secondary one in turn) were carried out 2-4 times a night. The calibrating values were approximated by polynomial of 1 or 2 degree and the interpolated values were added to magnitudes' differences V-C. All the light curves were jointed and an average for the data ($-1^m.017$) was subtracted from the united light curve.

We revealed that amplitudes of the light curves were significantly different for the first series of the data (from 8 to 16 Oct.) and for the second one (from 19 to 23 Oct.). Apparently, the "jump" in the values of amplitudes was a result of amplifiers' modernization. We used an advice of Pelt (1980) and normalized our data for mean dispersion. The mean dispersion including star's variability for the first set of the data was $0^m.0274$, for the second one - $0^m.0324$. Then all the data were multiplied by mean dispersion, $0^m.299$. This way we lost in amplitudes accuracy, but gained in frequencies determination.

The data set shown in fig.2 was analyzed by using package FOUR (Andronov, 1994). The amplitude Fourier spectrum of the data after successive pre-whitening is presented in fig.3, the revealed frequencies are given in Table 2.

The first frequency of our data coincide completely with f_1 of STEPPI93, the second frequency is one day alias, apparently, of frequency $f_4=10.82$ c/d in STEPPI93. Next frequency, 7.515 c/d, evidently, correspond to $f_2=6.52$ c/d, and frequencies 9.35 c/d and 9.48 c/d coincide with STEPPI93 solution. The next revealed frequency, 3.54 c/d, close to 3.5 c/d from McNamara & Horan (1984), but we regard it to noise due to small amplitude ($0^m.013$), which is comparable with the noise level.

The residuals ($0^m.012$) after 5-frequencies so-

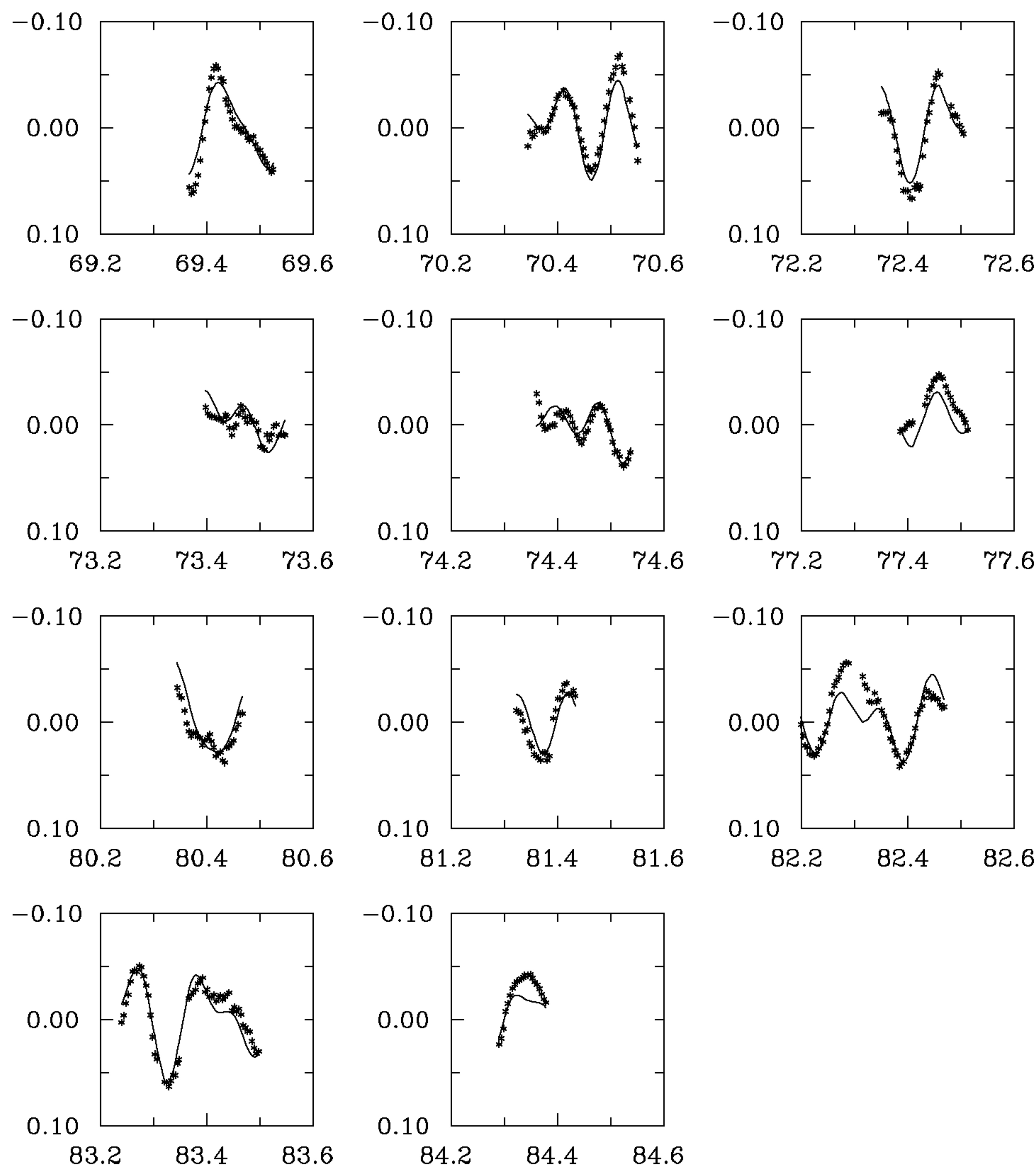


Figure 2: The light curves of VW Ari for 11 nights and their fit of 5-frequencies solution derived in this paper. The epoch is HJD 2449200+, amplitude is in mag

Table 2.

Frequency c/d	Amplitude mmag	Phase 2π rad
6.225 ± 0.001	21.5 ± 0.9	0.539
11.820 ± 0.001	18.4 ± 0.9	0.342
7.515 ± 0.002	17.9 ± 1.0	0.024
9.345 ± 0.002	15.2 ± 0.9	0.804
9.480 ± 0.003	10.9 ± 1.0	0.142
rms residual $\sigma = 0^m.012$		

lution are much more than a mean square error of a single observation ($0^m.001$) in each channel. A basic reason of the fact lies in calibrations uncertainties, which is amount of statistical and setting errors in both channels, differences in atmospheric extinction at the time of observations target star and comparison star and actually channel drifts. Due to these uncertainties the trends in differential light curves appear. The trends increase the noise level in frequency region below 25 c/d (see Breger & Handler, 1993) and lower the accuracy of frequencies determination. More reliable calibration system is needed. Apparently the inside

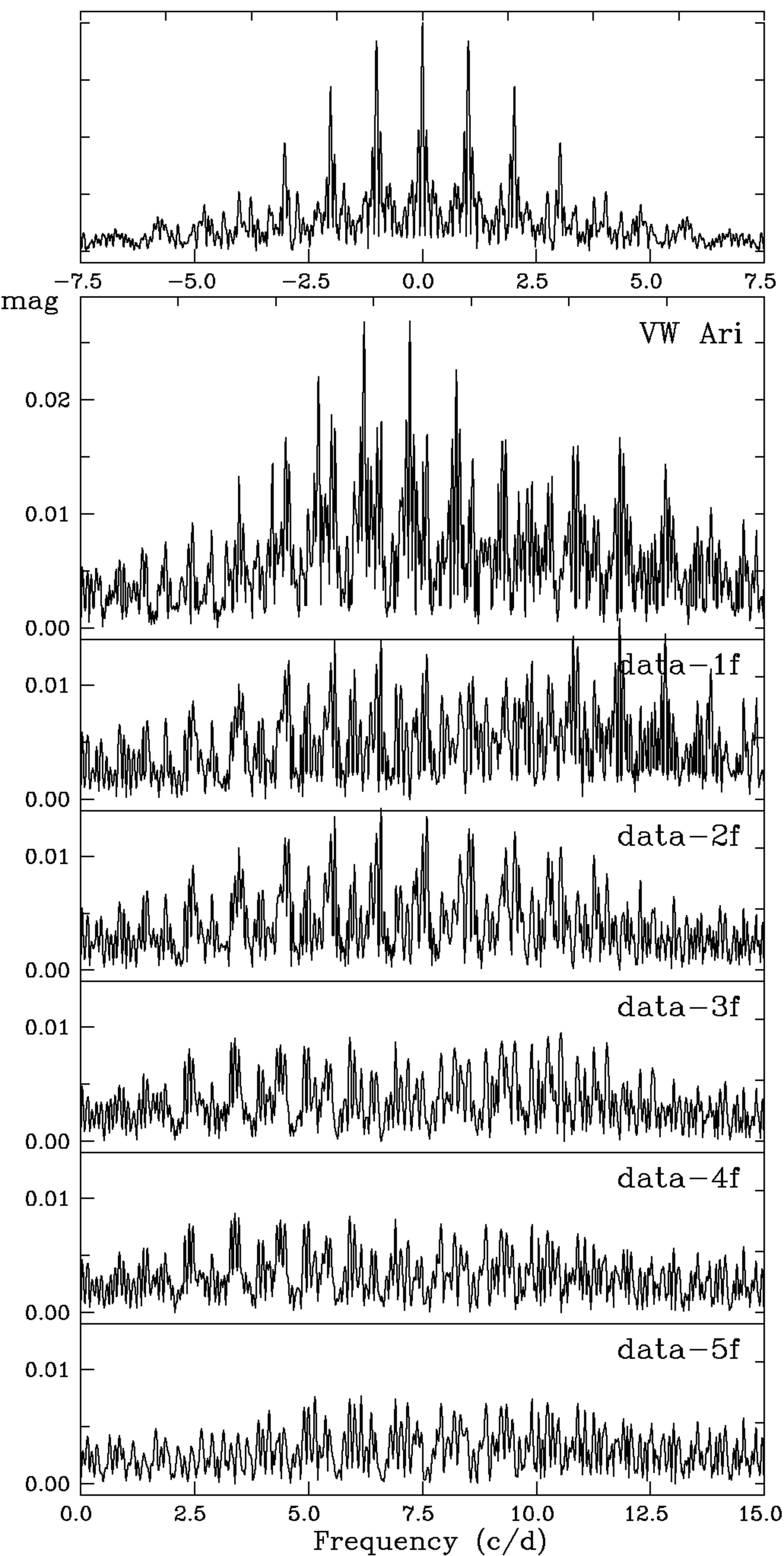


Figure 3: A spectral window and amplitudes' Fourier spectra of VW Ari before and after removal of one or more periods.

calibrations using a single artificial source for both channels is the most available. Such calibrations would be independent of sky transparency.

In this communication we presented the analysis of observations only at the Mt. Dushak-Erekdag observatory. Evidently it is difficulty

to obtain a correct solution for the star with such complete frequency spectrum and low amplitudes using the data of a single observatory. The separate data from Mt.Dushak-Erekdag and STEPPI established only the fact of existing 3 frequency group based on 6.2 c/d, 9.3 c/d, 10.8 c/d. All the data are united and the more accurate frequency solution will be presented in the next paper.

We would like to concern briefly the problem of mode identification for this star. Percy (1980) and Rucinsky (1978) assumed that 6 c/d relates to fundamental mode of the star. Kurtz (1980) supposed that 6.35 c/d (6.22 c/d in our data) is the first overtone of radial pulsation. Li & Jiang (1993) and Liu et al. (1997) were inclined to the opinion that only nonradial p-modes degree $l=2$ and $l=3$ presents in the star. These authors operated the well-known alignment for pulsation constant Q from Breger & Bregman (1975) and tables from Fitch (1981) for evolutionary models of the stars. McNamara & Horan (1984) and Li & Jiang (1993) undertook the searches of frequency splitting in the suggestion that the star rotates slowly (less than 20 km/sec.) according to conjecture by Rucinsky (1978). But Abt (1980) claimed $v \sin i = 90 \pm 10$ km/sec. It should be noted that important problem of rotate velocity of VW Ari has not been solved yet.

The supposition on high rotation velocity of VW Ari was made by our colleagues on the basis of 8 Å/mm spectra (Andrievsky et al., 1995). The effect of equidistant frequency splitting is not observed for rapidly rotating stars (Ledoux, 1951). Andrievsky (1997) drew attention that VW Ari may be related to a little group of λ Booti stars (see Gray & Corbally, 1993). A strong metal deficiency and rapid rotation are the typical characteristics of these stars being actively investigated now. The pulsations of λ Booti stars like that in δ Scuti stars are detected recently (see, for example Weiss et al., 1994).

The mode identification by using Fitch (1981) tables may be inaccurate taking into account these reasons. The model values as well as were made for BN and BU Cancri, for exam-

ple (see Perez Hernandez et al., 1995) should provide more reasonable identification.

Acknowledgments. Expedition from Odessa to the Mt. Dushak- Erekdag in 1993 was carried out thanks to financial support from funds of "Polis" association, the authors are grateful to M. Torosian. First from the authors is much obliged to Dr. I.L. Andronov for helpful discussions.

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CYCLE-TO-CYCLE CHANGES IN THE MIRA-TYPE STAR RT CYG

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ABSTRACT. RT Cyg was observed on photographic negatives of the Odessa plate collection. These data were reduced to the visual AFOEV system. The complete data set ($n = 7154$) was studied by using several methods described by Andronov (1997b). 3-rd order trigonometric polynomial fit to the mean light curve corresponds to the period $P = 190^d.162 \pm 0^d.003$ (coinciding with the value listed in GCVS (Kholopov et al., 1987) and asymmetry 0.458 (0.44 in GCVS). The characteristics of the cycles are determined and studied by using the correlation analysis.

Key words: Stars: Mira-type, RT Cyg

Introduction

RT Cyg is one among well studied stars which monitoring during decades was carried out by the amateur astronomers. According to GCVS IV (Kholopov et al. 1985) the brightness varies from $6^m.0$ to $13^m.1$ (V), the ephemeris for maximum is the following:

$$MaxHJD = 2444588 + 190.166 \cdot E \quad (1)$$

The asymmetry is equal to $A = 0.44P$. We used both photographic and visual observations to study temporal behavior of the brightness as the initial characteristic, and of the parameters of the individual cycles as characteristics of the pulsations.

Photographic Observations

The brightness of the star was measured on 292 photographic negatives of the Sky Patrol of the Astronomical Observatory of the Odessa State University. The photographic brightness

of comparison stars was published by Strelkova (1953). After removing the estimates "fainter than" 269 data points remained. The range of brightness variations $7^m.00 - 13^m.61$ (pg).

The periodogram analysis was carried out by using the computer code FOUR-M by Andronov (1994) for multi-harmonic approximation. The test function $S(f) = \sigma_{O-C}^2 / \sigma_O^2$ vs. trial period is shown at Fig. 1. The minimum value of $S(f)$ corresponds to 190^d , i.e. to the value known before. Other minima apparently occur at the trial periods $2P$ and $2P/3$.

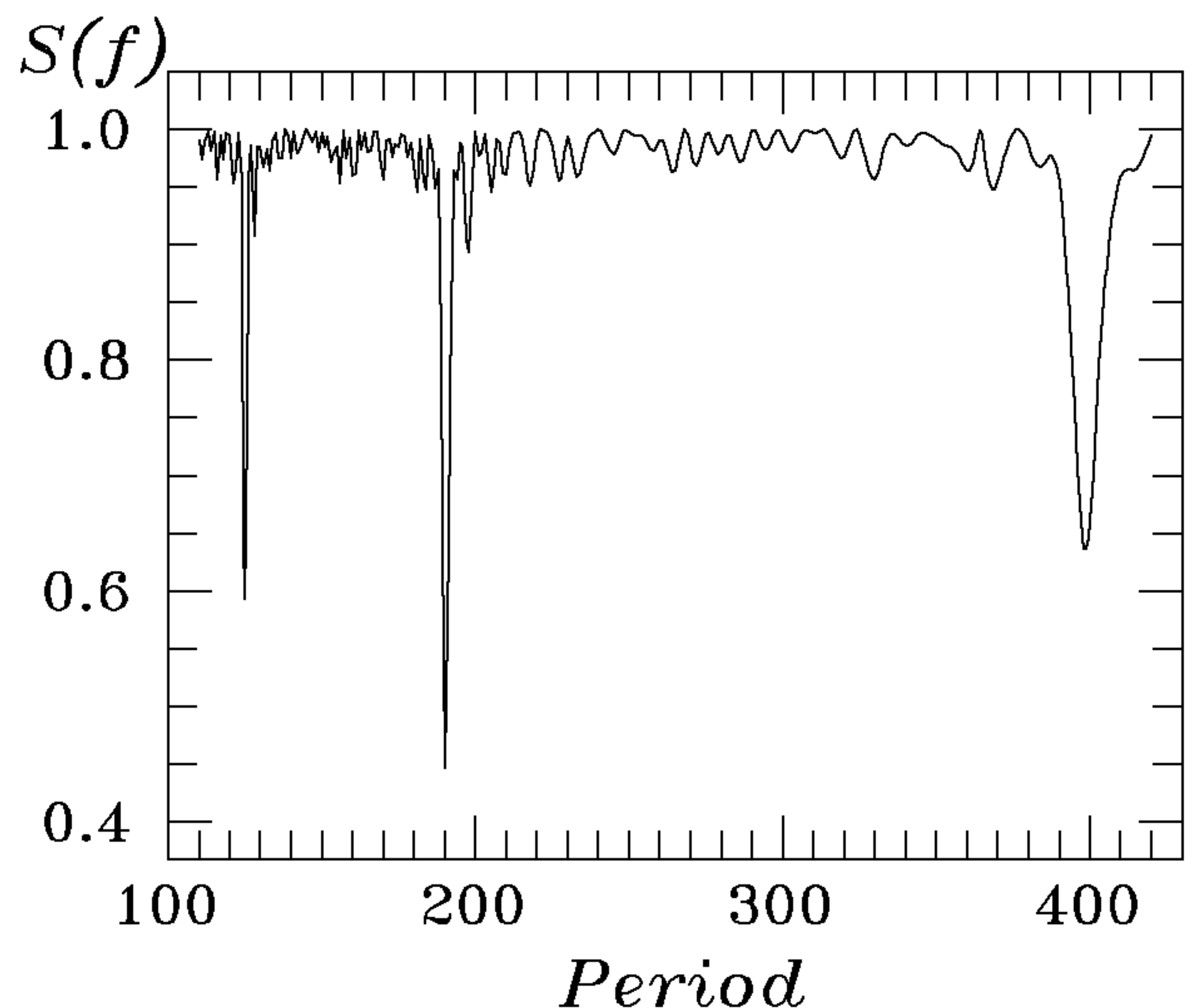


Figure 1. Test function $S(f) = \sigma_{O-C}^2 / \sigma_O^2$ for RT Cyg.

The statistically significant order of trigonometrical polynomial for these observations is $m = 2$. By using differential corrections, we have obtained the period value $P = 190.28 \pm 0.08$ for $m = 2$ coinciding with that listed in GCVS IV. However, the estimates of the asym-

Table 1. Results of trigonometrical polynomial fit of the phase light curves using photographic, visual (AFOEV) and whole series of observations. s is order of the trigonometrical polynomial, P is a mean period, also mean asymmetry, amplitude and magnitudes in maximum and minimum are listed.

Data	s	P	Asym.	Ampl.
Pg	2	190.28	0.405	4.19
		± 0.04	± 0.009	± 0.06
AFOEV	3	190.166	0.462	4.52
		pm 0.003	± 0.003	± 0.02
All	3	190.162	0.458	4.54
		± 0.003	± 0.003	± 0.02

Data	m_{max}	m_{min}
Pg	7.37	11.56
	± 0.06	± 0.09
AFOEV	7.42	11.94
	± 0.02	± 0.02
All	7.40	11.94
	± 0.02	± 0.02

metry $A = 0.405$ for $m = 2$ differ from the value 0.44 listed in the GCVS. The possible explanations are the difference of the lightcurves in visual and photographic systems and variations of the asymmetry in the interval covered by photographic observations.

AFOEV Data

The observations were made by the members of the AFOEV (JD 2422897-50169). The AFOEV database was described by Schweitzer (1993). From all data we deleted not sure values and estimates "fainter than". We thank the amateur astronomers for their intensive studies.

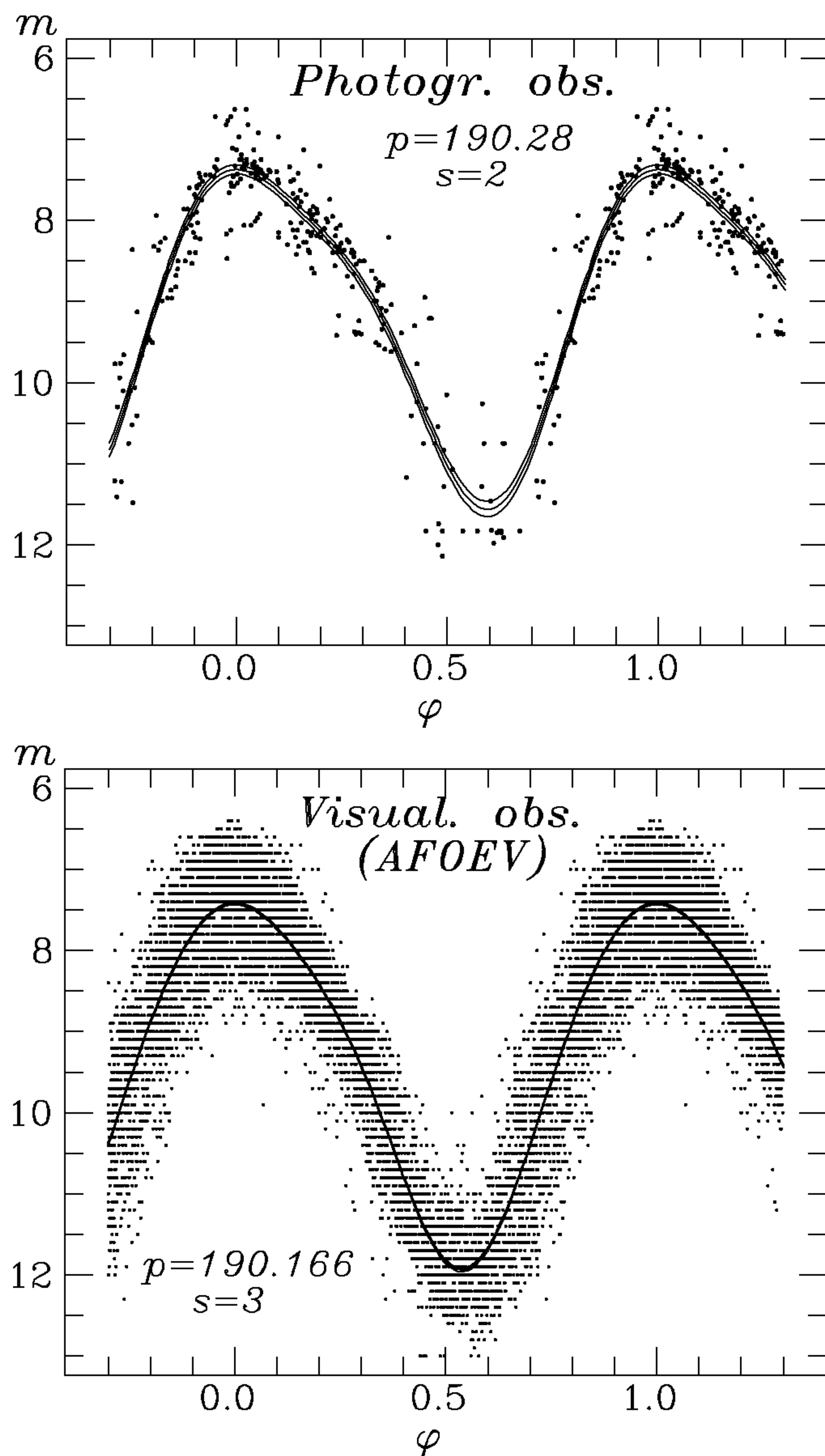


Figure 2. Photographic (up) and visual (bottom) phase light curve of RT Cyg. The lines correspond to the smoothing function and 3σ deviations from it.

Table 2. Amplitudes r_i and phase ϕ_i of waves of trigonometrical polynomial fit for photographic and AFOEV observations.

Photographic		
number of waves	r_i	ϕ_i
1	2.000 ± 0.049	0.067 ± 0.004
2	0.409 ± 0.045	-0.240 ± 0.017
AFOEV		
number of waves	r_i	ϕ_i
1	2.194 ± 0.010	0.028 ± 0.001
2	0.286 ± 0.010	-0.368 ± 0.006
3	0.050 ± 0.010	0.037 ± 0.031

Table 3. Characteristics of extrema: moments and their error estimates; magnitudes and their error estimates.

T		m	T		m	T		m
Maxima			44400.5 $\pm$ 2.0	7.41 $\pm$ 0.08		27962.9 $\pm$ 1.0	12.38 $\pm$ 0.05	
22907.1 $\pm$ 1.5	7.06 $\pm$ 0.07		44589.7 $\pm$ 2.1	7.44 $\pm$ 0.03		28145.2 $\pm$ 0.7	11.88 $\pm$ 0.07	
23095.3 $\pm$ 2.2	7.06 $\pm$ 0.08		44774.2 $\pm$ 3.3	6.97 $\pm$ 0.07		28350.1 $\pm$ 5.0	12.25 $\pm$ 0.09	
23270.7 $\pm$ 1.3	6.86 $\pm$ 0.05		29490.7 $\pm$ 1.7	12.02 $\pm$ 0.08		28534.0 $\pm$ 1.1	12.60 $\pm$ 0.03	
23472.7 $\pm$ 1.3	7.81 $\pm$ 0.05		44970.5 $\pm$ 1.4	8.12 $\pm$ 0.06		28724.3 $\pm$ 1.3	12.02 $\pm$ 0.09	
23669.7 $\pm$ 1.0	7.68 $\pm$ 0.05		45147.2 $\pm$ 0.9	7.31 $\pm$ 0.06		28919.3 $\pm$ 2.0	11.94 $\pm$ 0.07	
23864.9 $\pm$ 0.6	7.22 $\pm$ 0.06		45347.3 $\pm$ 1.3	7.48 $\pm$ 0.08		29097.3 $\pm$ 1.2	11.32 $\pm$ 0.09	
24047.0 $\pm$ 0.6	7.32 $\pm$ 0.03		45543.7 $\pm$ 0.9	7.08 $\pm$ 0.03		29293.2 $\pm$ 1.0	11.92 $\pm$ 0.06	
26152.7 $\pm$ 2.5	7.21 $\pm$ 0.04		45732.0 $\pm$ 1.6	7.18 $\pm$ 0.12		29859.4 $\pm$ 1.1	11.93 $\pm$ 0.11	
26335.6 $\pm$ 1.2	6.89 $\pm$ 0.04		45917.8 $\pm$ 0.5	6.99 $\pm$ 0.04		30245.7 $\pm$ 5.0	11.88 $\pm$ 0.17	
26514.0 $\pm$ 2.1	7.31 $\pm$ 0.05		46109.9 $\pm$ 3.0	7.50 $\pm$ 0.10		31003.5 $\pm$ 2.0	11.18 $\pm$ 0.11	
26712.3 $\pm$ 1.5	6.86 $\pm$ 0.07		46309.4 $\pm$ 2.0	7.59 $\pm$ 0.04		39733.8 $\pm$ 2.3	11.81 $\pm$ 0.13	
26901.1 $\pm$ 0.9	6.88 $\pm$ 0.04		46498.1 $\pm$ 1.5	7.35 $\pm$ 0.05		39937.6 $\pm$ 1.2	11.78 $\pm$ 0.17	
27103.3 $\pm$ 0.8	7.26 $\pm$ 0.04		46681.4 $\pm$ 0.6	6.77 $\pm$ 0.03		40117.8 $\pm$ 0.9	11.69 $\pm$ 0.11	
27289.0 $\pm$ 1.5	7.36 $\pm$ 0.06		46889.8 $\pm$ 3.4	8.51 $\pm$ 0.06		40320.4 $\pm$ 3.5	12.28 $\pm$ 0.11	
27477.6 $\pm$ 1.7	7.33 $\pm$ 0.08		47060.7 $\pm$ 1.2	7.60 $\pm$ 0.04		40489.5 $\pm$ 2.4	12.31 $\pm$ 0.08	
27662.2 $\pm$ 1.0	6.71 $\pm$ 0.05		47268.3 $\pm$ 1.0	7.72 $\pm$ 0.05		41078.7 $\pm$ 3.7	12.06 $\pm$ 0.13	
27861.0 $\pm$ 3.8	8.15 $\pm$ 0.04		47440.5 $\pm$ 0.8	7.29 $\pm$ 0.03		41263.0 $\pm$ 3.4	11.67 $\pm$ 0.11	
28057.2 $\pm$ 1.1	7.79 $\pm$ 0.04		47626.4 $\pm$ 2.0	6.83 $\pm$ 0.05		42219.0 $\pm$ 1.1	11.28 $\pm$ 0.10	
28241.4 $\pm$ 2.6	6.71 $\pm$ 0.11		47828.6 $\pm$ 0.4	7.91 $\pm$ 0.02		42602.0 $\pm$ 2.7	11.68 $\pm$ 0.17	
28435.2 $\pm$ 1.2	8.08 $\pm$ 0.04		48013.0 $\pm$ 0.8	7.20 $\pm$ 0.04		42978.1 $\pm$ 1.8	12.25 $\pm$ 0.11	
28617.9 $\pm$ 1.9	7.95 $\pm$ 0.07		48204.1 $\pm$ 0.9	8.02 $\pm$ 0.02		43367.0 $\pm$ 1.5	11.47 $\pm$ 0.12	
28808.5 $\pm$ 2.0	7.36 $\pm$ 0.06		48387.6 $\pm$ 1.7	7.16 $\pm$ 0.04		43741.0 $\pm$ 0.8	11.80 $\pm$ 0.14	
28997.7 $\pm$ 2.0	7.42 $\pm$ 0.06		48575.1 $\pm$ 0.8	7.80 $\pm$ 0.03		44120.0 $\pm$ 0.8	11.99 $\pm$ 0.07	
29191.4 $\pm$ 1.2	7.02 $\pm$ 0.04		48770.7 $\pm$ 0.8	6.97 $\pm$ 0.03		44508.9 $\pm$ 1.2	11.80 $\pm$ 0.08	
29382.5 $\pm$ 2.2	7.70 $\pm$ 0.05		48954.3 $\pm$ 1.8	7.77 $\pm$ 0.03		44883.0 $\pm$ 1.2	12.53 $\pm$ 0.08	
29566.5 $\pm$ 1.4	7.81 $\pm$ 0.05		49145.4 $\pm$ 0.6	6.70 $\pm$ 0.03		45065.9 $\pm$ 1.8	11.70 $\pm$ 0.10	
29951.1 $\pm$ 2.7	8.13 $\pm$ 0.06		49336.5 $\pm$ 1.2	7.20 $\pm$ 0.04		45263.8 $\pm$ 1.7	12.18 $\pm$ 0.08	
30329.8 $\pm$ 9.2	8.37 $\pm$ 0.08		49526.3 $\pm$ 0.8	7.48 $\pm$ 0.03		45453.5 $\pm$ 0.9	12.30 $\pm$ 0.09	
30702.7 $\pm$ 2.5	7.12 $\pm$ 0.08		49723.2 $\pm$ 1.7	6.96 $\pm$ 0.03		45645.3 $\pm$ 0.7	12.27 $\pm$ 0.07	
30919.9 $\pm$ 1.3	8.08 $\pm$ 0.03		49912.2 $\pm$ 0.8	8.15 $\pm$ 0.02		45829.3 $\pm$ 1.3	11.83 $\pm$ 0.13	
31093.1 $\pm$ 1.5	6.37 $\pm$ 0.12		50090.3 $\pm$ 0.5	7.33 $\pm$ 0.03		46019.9 $\pm$ 1.6	12.08 $\pm$ 0.08	
34714.3 $\pm$ 2.5	7.12 $\pm$ 0.09		Minima			46407.8 $\pm$ 1.1	11.82 $\pm$ 0.12	
36406.1 $\pm$ 0.7	7.40 $\pm$ 0.04		23003.4 $\pm$ 0.7	12.02 $\pm$ 0.05		46591.3 $\pm$ 0.6	11.07 $\pm$ 0.05	
39644.3 $\pm$ 2.6	8.07 $\pm$ 0.06		23179.5 $\pm$ 0.9	11.45 $\pm$ 0.06		46788.8 $\pm$ 2.4	12.61 $\pm$ 0.10	
40003.1 $\pm$ 2.6	7.66 $\pm$ 0.12		23387.5 $\pm$ 0.8	12.02 $\pm$ 0.04		46972.6 $\pm$ 0.7	12.51 $\pm$ 0.09	
40403.3 $\pm$ 2.5	8.56 $\pm$ 0.06		23571.6 $\pm$ 1.1	11.59 $\pm$ 0.07		47168.4 $\pm$ 1.8	12.22 $\pm$ 0.10	
40775.9 $\pm$ 3.0	8.21 $\pm$ 0.06		23766.8 $\pm$ 0.9	11.64 $\pm$ 0.06		47358.9 $\pm$ 0.7	11.89 $\pm$ 0.04	
41166.7 $\pm$ 2.3	8.15 $\pm$ 0.04		23953.1 $\pm$ 1.0	11.90 $\pm$ 0.06		47545.5 $\pm$ 1.3	11.34 $\pm$ 0.08	
41541.1 $\pm$ 1.5	6.93 $\pm$ 0.10		24146.4 $\pm$ 1.6	11.56 $\pm$ 0.05		47734.3 $\pm$ 0.9	12.46 $\pm$ 0.05	
41912.1 $\pm$ 5.7	7.72 $\pm$ 0.18		24341.4 $\pm$ 1.2	12.07 $\pm$ 0.08		48113.4 $\pm$ 0.5	12.27 $\pm$ 0.05	
42304.1 $\pm$ 2.6	7.22 $\pm$ 0.11		26059.6 $\pm$ 1.5	11.75 $\pm$ 0.08		48299.0 $\pm$ 1.1	11.87 $\pm$ 0.15	
42684.9 $\pm$ 0.8	6.67 $\pm$ 0.05		26241.0 $\pm$ 1.2	11.81 $\pm$ 0.06		48493.5 $\pm$ 0.6	12.30 $\pm$ 0.04	
42870.8 $\pm$ 11.3	7.89 $\pm$ 0.10		26438.5 $\pm$ 0.9	11.97 $\pm$ 0.07		48872.8 $\pm$ 0.7	11.49 $\pm$ 0.04	
43080.9 $\pm$ 2.7	7.32 $\pm$ 0.09		26624.5 $\pm$ 0.9	11.52 $\pm$ 0.07		49058.7 $\pm$ 1.9	11.52 $\pm$ 0.17	
43261.5 $\pm$ 3.2	7.63 $\pm$ 0.08		26810.6 $\pm$ 1.0	11.72 $\pm$ 0.10		49249.1 $\pm$ 0.6	11.44 $\pm$ 0.06	
43444.0 $\pm$ 1.6	7.04 $\pm$ 0.05		27014.0 $\pm$ 1.2	12.27 $\pm$ 0.07		49439.6 $\pm$ 1.1	12.00 $\pm$ 0.13	
43628.7 $\pm$ 1.6	6.92 $\pm$ 0.17		27202.4 $\pm$ 0.9	12.16 $\pm$ 0.06		49629.0 $\pm$ 0.6	11.89 $\pm$ 0.06	
43830.3 $\pm$ 1.6	7.09 $\pm$ 0.06		27390.1 $\pm$ 0.9	12.26 $\pm$ 0.05		49816.0 $\pm$ 1.5	12.96 $\pm$ 0.12	
44029.0 $\pm$ 2.1	7.91 $\pm$ 0.04		27575.6 $\pm$ 1.2	11.50 $\pm$ 0.09		50010.3 $\pm$ 0.9	12.19 $\pm$ 0.06	
44206.4 $\pm$ 0.8	6.93 $\pm$ 0.04		27771.5 $\pm$ 0.7	12.01 $\pm$ 0.05				

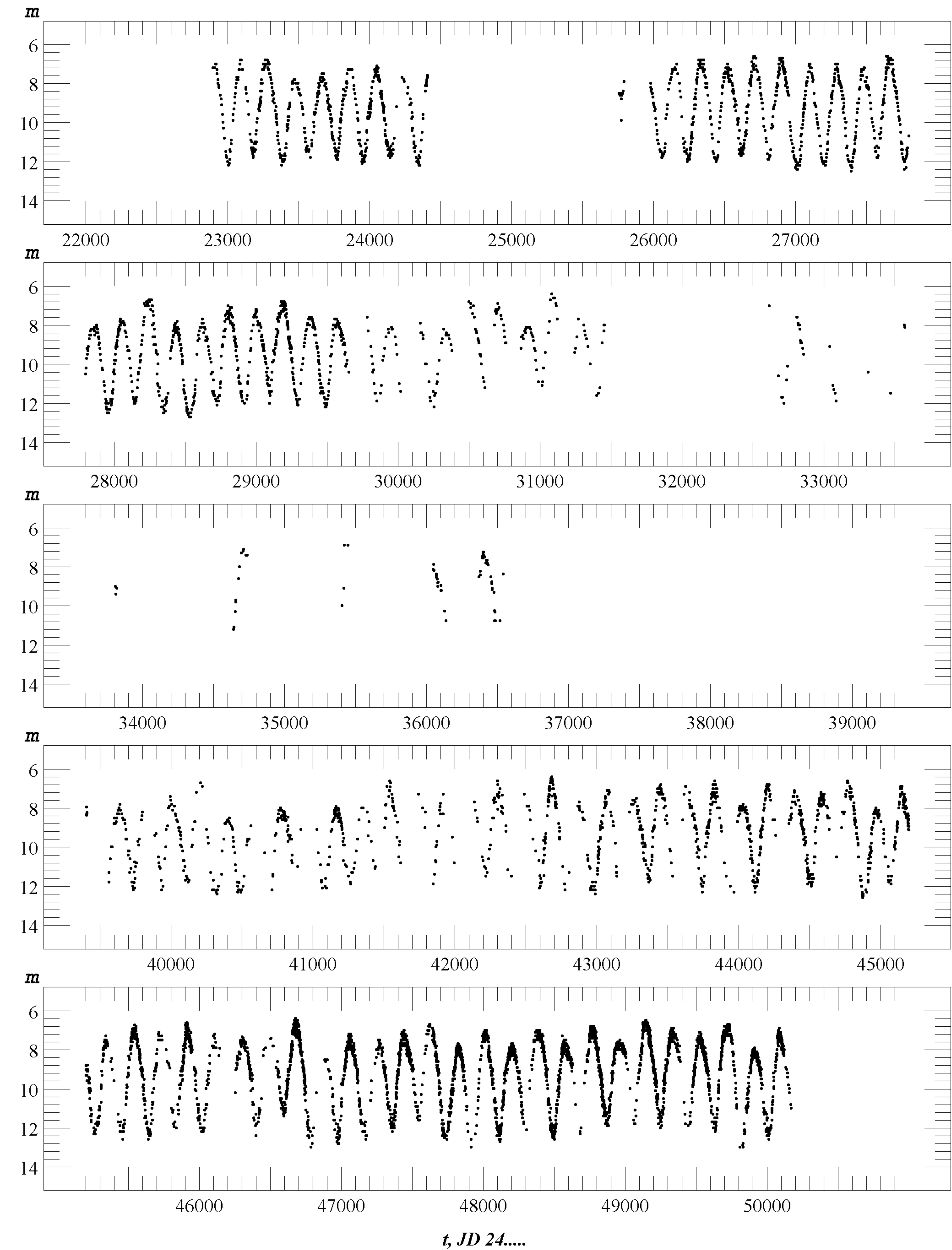


Figure 3. Visual and reduced photographic observations of RT Cyg

The light curve was fitted by the method of "running parabolaes" (Andronov, 1990, 1997a). The best fit value of the filter half-width maximizing the "signal/noise" ratio was found to be 50^d . This parameter was used to compute the smoothed values at the times of our photographic observations. Then a characteristic curve $m_{vis}(m_{pg})$ was approximated by a parabola, and our photographic values were transformed to the AFOEV visual system. For further analysis altogether 7521 data points were used.

Phase light curves for visual, photographic and whole series of the observations are shown in the Fig. 2. Tables 1-2 include characteristics of these light curves in three case and amplitudes and phases of waves for photographic and visual observations for comparison.

The whole light curve is presented in Fig. 3. The graph was created by using the program by Shapovalova (1997).

Characteristics of the individual cycles

The "running parabolaes" fit was recomputed for all these observations, and the time and brightness of the extrema was determined with corresponding error estimates as described by Andronov (1997a). Characteristics of extrema are listed in the Table 3.

Next step is to determine the following parameters of the individual cycle: the central maximum (marked as "0"), previous and next maxima ("1" and "2"), previous and next minima ("3" and "4"). The times t and magnitudes m were used also to compute characteristics $t_{ij} = t_i - t_j$. The set of parameters was determined for each from 81 individual maxima. Obviously, some parameters for a trial maximum could be absent, thus the correlation coefficient r was computed for smaller number of pairs. Results are shown in Table 5. For easier reading, we have also computed the ratio r/σ_r , where $\sigma_r^2 = (1-r^2)/(n-2)$ is the error estimate of r (cf. Whittaker and Robinson 1926). As a rough criterion of the presence of statistically significant correlation one may use $|r/\sigma_r| > 3$.

Most significant ($\frac{r}{\sigma_r} \geq 4$ and not trivial correlations are listed in Table 4. It is notable

Table 4. Most significant correlations

Parameters		r	$\frac{r}{\sigma_r}$	Number of pairs
m_{02}	m_{34}	79.4119	84.6792	44
m_2	m_4	70.7519	72.8860	55
m_0	m_3	63.9637	64.9913	63
m_2	m_{34}	-70.8096	64.9892	44
m_2	m_{40}	63.9982	60.6351	55
m_3	m_{02}	59.5199	52.8956	53
m_{02}	t_{34}	-58.1279	46.2959	44
m_{40}	t_{34}	55.7654	45.5646	48
t_{01}	m_{01}	46.9793	41.9036	64
m_2	t_{34}	53.6266	41.1753	44
m_3	m_{01}	48.5442	40.0400	54

that amplitude is in average constant (correlations between $\rho(m_0, m_3)$); and mean brightness vary smoothly ($\rho(m_{02}, m_{34})$), these variations and depends on period between minima (t_{34}). Also we can note correlation between amplitude (of descending branch) and period between minima.

The correlation $\rho(m_{02}, m_{34})$ is similar to one appeared in W Lyr (Marsakova and Andronov, 1997). Also it seen similarity in the correlations $\rho(m_2, m_{40})$ (RT Cyg) and $\rho(m_2, m_{30})$ (W Lyr): between brightness in next maximum and amplitude of descending or ascending branch, respectively.

The whole table may be used for comparison with theoretical models of "weak chaos" in the pulsations of the Mira-type stars.

The dependence of all these parameters on time was also studied. There are long-term changes onto which more rapid variations are superimposed. One may see e.g. the (O-C) diagram for maxima and minima and the fits suggesting the shift between maxima and minima is constant. Formally the polynomial of 4th order is statistically significant, but it only shows decade-scale cyclicity.

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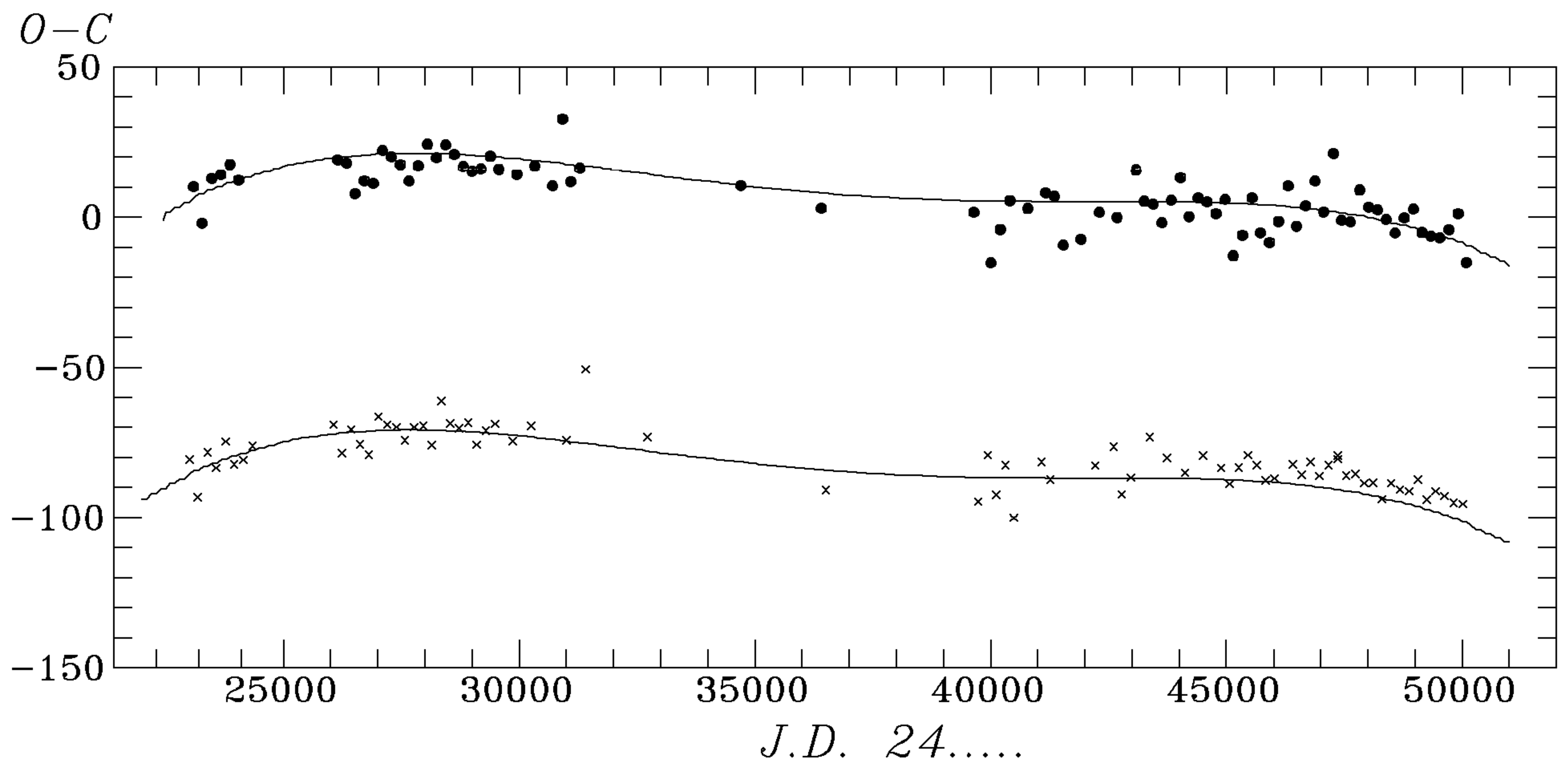


Figure 4. O-C diagram for maxima (above) and minima (below). The linear and 4th- order polynomial fits are shown.

Table 5. Correlation coefficients r between different characteristics of the light curve of RT Cyg. Below the diagonal: $100 \cdot r$; above the diagonal: r/σ_r .

	m_0	m_{30}	m_{40}	m_1	m_2	m_3	m_4	t_{01}	t_{20}	t_{03}	m_{30}	t_{40}	m_{40}	m_{01}	m_{02}	m_{34}	t_{43}	$\frac{t_{03}}{t_{43}}$	$\frac{t_{03}}{t_{01}}$
m_0	*	1	1	-2	-2	6	-0	4	-3	-0	-7	-4	-10	11	11	4	-4	2	-2
m_{30}	8	*	1	-0	-4	-1	-5	-1	-0	-3	-1	1	-4	1	3	3	-0	-1	-3
m_{40}	16	10	*	1	-2	4	-1	-1	-1	-3	2	-0	-2	1	2	3	-3	-1	-3
m_1	-29	-3	11	*	0	-0	-0	-3	0	-0	2	1	1	-11	-2	0	1	-0	2
m_2	-29	-44	-25	6	*	-2	7	-1	4	2	0	3	6	-2	-11	-6	4	-1	2
m_3	64	-6	44	-6	-22	*	1	2	-3	1	1	-3	-4	4	5	6	-2	2	-0
m_4	-4	-55	-15	-4	71	9	*	-0	2	1	0	1	6	-0	-4	-6	2	0	1
t_{01}	41	-7	-9	-35	-10	29	-3	*	-4	4	-1	-6	-2	4	2	0	-2	5	-2
t_{20}	-35	-5	-14	4	41	-42	29	-48	*	-3	-0	8	4	-2	-4	-4	4	-6	-1
t_{03}	-1	-40	-37	-4	22	16	22	50	-40	*	1	-4	1	0	-0	-0	2	10	8
m_{30}	-66	-14	24	29	2	16	7	-18	-2	17	*	1	4	-5	-3	1	2	-0	2
t_{40}	-45	14	-0	9	39	-37	16	-66	74	-52	14	*	4	-3	-4	-3	6	-13	-1
m_{40}	-79	-49	-20	14	64	-47	65	-31	47	15	54	44	*	-5	-14	-9	5	-1	2
m_{01}	81	10	8	-80	-22	49	-1	47	-27	6	-53	-36	-59	*	6	2	-3	2	-2
m_{02}	80	37	27	-21	-81	60	-49	30	-47	-5	-37	-50	-89	64	*	8	-5	2	-2
m_{34}	48	40	45	5	-71	67	-67	6	-50	-7	7	-35	-80	30	79	*	-3	1	-1
t_{43}	-47	-5	-38	19	54	-31	30	-35	48	30	29	66	56	-39	-58	-45	*	-2	4
$\frac{t_{03}}{t_{43}}$	30	-14	-10	-5	-10	30	1	57	-69	85	-6	-89	-22	24	26	21	-32	*	3
$\frac{t_{03}}{t_{01}}$	-24	-37	-41	24	30	-5	15	-22	-9	73	28	-8	23	-31	-30	-13	52	45	*

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BURST GALAXIES

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ABSTRACT. Here we present observational evidences and theoretical approaches to the starburst phenomena in the different types of the galaxies. A starburst model for AGN, large-scale gas outflow of the central regions of galaxies, and ultimate fate of a matter venting out of a starforming regions are discussed.

Key words: galaxies: kinematics and dynamics; interstellar matter; shock waves.

Introduction

Starburst galaxies are among the most interesting and puzzling objects drawn a great attention during the last decade. There are several reasons for a continuously rising interest to this objects which includes both of new observational programs and comprehensive theoretical models. They could be summarized as follows:

- an extreme energy release rate in the local space regions;
- a possible crucial role in the dynamic and chemical evolution of galaxies;
- the cosmological scenarios and mechanisms of galaxies formation itself;
- the galactic - intergalactic medium connection and X-ray background;
- a possible link with the basic properties of AGNs;
- starburst dwarf galaxies are the ideal laboratories for studying star formation itself.

Below in this paper we define starburst galaxies as the systems with a powerful cluster of young massive stars and highly ionized gas in

the central kpc region with the characteristic time for a gas depletion

$$\tau_{dep} = \frac{M_{gas}}{SFR} \ll \tau_{gal} \quad (1)$$

much smaller than a characteristic time-scale for a galaxy evolution. Here SFR is the star formation rate.

Starburst far-IR galaxies.

Stellar winds and SN explosions from a compact star cluster provide a powerful gas outflow and coherent shell formation around a central regions of starburst galaxies. There are three main observational evidences for a galactic-scale superwinds in these systems (Heckman et al. 1990).

- *Physical.* Strong shock wave formation and emission-line ratios inherent of material that has been shock heated;
- *Morphological.* Large-scale regions of optical, X-ray, and continuous radio emission with the main axis normal to the galaxy plane of symmetry, sometimes they are strong limb brightened;
- *Kinematic.* A double-peaked emission line profiles which cover a kpc-scale regions.

All these signatures are well defined in the edge-on far-infrared galaxies (FIRGs) that have been observed by Heckman et al. (1990). The sample of 14 galaxies includes the three nearest FIRGs M82, NGC253, NGC 4945, and the most luminous far-IR galaxy IRAS 001182-7112. The observed parameters of the starburst regions are summarized in the Table 1.

These values give an estimation for the total starburst energy $E_{burst} \approx P\Omega \approx 10^{56} - 10^{58}$

ergs, the average energy and mass input rates $L_{burst} = E_{burst}/\tau_{burst} \approx 3 \times (10^{41} - 10^{43}) \text{ erg s}^{-1}$, $\dot{M} \approx 4L_{IR,11} M_{\odot} \text{ yr}^{-1}$, and the rate of supernova explosions $\nu_{SN} \approx 0.2 L_{IR,11} \text{ yr}^{-1}$ (Heckman et al., 1990).

Table 1. Starburst parameters in the far-IR galaxies.

Star cluster size	$< 1 \text{ kpc}$
Shell, X-ray region size	$1\text{-}50 \text{ kpc}$
$L_{H\alpha}$	$10^{40} - 10^{42} \text{ erg s}^{-1}$
L_{bol}	up to $10^{46} \text{ erg s}^{-1}$
ΔV	$200\text{-}600 \text{ km s}^{-1}$
n_e	$(0.5 - 1) \times 10^3 \text{ cm}^{-3}$
P/k	$(1\text{-}3) \times 10^7 \text{ K cm}^{-3}$
τ_{burst}	$\approx 10^7 \text{ yr}$

Seyfert galaxies.

It has long time been known that nuclei of Seyfert galaxies to be the sites of small-scale subkiloparsec radio emission. However the last years WSRT systematic study of the 13 Seyfert galaxies revealed also a diffuse large-scale radio components (Baum et al. 1993). The ratio of the extra-nuclear radio emission to the far-IR flux is in a good agreement with the empirical relationship found for the extragalactic star-forming regions. Regions of the large-scale radio emission are often not spherical, sometimes limb-brightened, with the main axis to be aligned with the minor axis of the galaxy. Thus the observed large-scale diffuse radio emission is not an extension of the nuclear radio jets like the radio lobes in the powerful radio galaxies. It's radio powers at 1.4 GHz is compared with the radio power of the prototype starburst galaxy M82 ($10^{22} \text{ W Hz}^{-1}$), and starburst scenario is highly suggestive for explanation of high energy electrons and diffuse large-scale radio emission.

Dwarf galaxies.

Dwarf galaxies play a crucial role in the study of star formation, formation and evolution of galaxies. In the popular cosmological scenarios they were the first blocks for the current structure of the Universe. The most

metal-poor dwarfs like I Zw18 probably undergo a first burst of star formation, another ones are the ideal laboratories for studying star formation itself because they are free of the contamination influence of the outside star forming regions, fast galactic rotation etc. Star-forming dwarf galaxies fall primary into two morphological classes.

- *Dwarf amorphous galaxies* have centrally condensed light distribution. It is suspected they went through a powerful burst of star formation in their history.
- *Magellanic irregular galaxies* are more homogeneous in the light distribution, and are consistent with a steady rate of star formation.

Marlowe et al. (1995) have presented a detailed study of the 7 nearby amorphous dwarf galaxies with a clear evidence for a violent star formation activity. All the galaxies present evidence for a kiloparsec-scale hollow structures (superbubbles) which typically expand with a velocity $30\text{-}60 \text{ km s}^{-1}$. The major axes of the cavities are preferentially aligned with the minor optical axes of the galaxies. The observed H_{α} luminosities fall in the range $10^{39} - 10^{41} \text{ erg s}^{-1}$, with the mean value of about an order of magnitude smaller, than in the far-IR galaxies. The estimated rate for a supernova explosions is then 1SN per $3 \times 10^2 - 10^3 \text{ yr}$.

Hydrodynamics of starburst galaxies.

An evolutionary trend for a powerful star cluster evolved in a dense gas condensation is highly depend on the ambient gas density and the rate of supernova explosions. It is easy to catch this dependence from the McKee and Ostriker (1977) relation for a tenuous hot gas volume filling factor:

$$f_V = 1 - \exp(-Q_{SN}), \quad (2)$$

where $Q_{SN} = 53 E_{51}^{1.28} S_{-11} n_0^{-0.14} P_4^{-1.3}$, E_{51} is the explosion energy per supernova in 10^{51} ergs units, S_{-11} is the supernova rate in the units

10^{-11} supernovae per year in pc^3 , P_4 is the ambient gas pressure in $10^4 k$ units. Analysis of this criterion leads immediately to two possible evolutionary trends, which are shown schematically in the figure 1. For a high density medium which may be suspected for a pre-starburst region, and low rate of supernova explosions any SNR may be considered as an isolated system and one gets a starburst model for AGN which has been firstly proposed by Shklovskii (1960) and then revived and fully developed by Terlevich and Melnick (1985), Terlevich et al. (1992), (figure 1a).

However, starburst parameters found in the discussed above FIRGs and dwarf galaxies lead to another regime with a coherent shell formation and large-scale gas outflow of the central starburst region (figure 1b). There is a common believe that in the dwarf galaxies shell distortion due to Rayleigh-Taylor instabilities allows the processed matter to flow away of the galaxy, and in extreme cases bubble expansion may result in a full loss of the ISM throughout the galaxy (De Young and Heckman, 1994). However, this conclusion is based on the numerical calculations for a shock propagation in the plane-stratified, disk-like gas distribution. In fact several well studied dwarfs exhibit an extending low density HI envelopes, which highly exceed an optical size of the galaxies. Thus, in the real systems at least two different gaseous components may be assumed. There are a dense galaxy disk and a low-density halo. Therefore a natural next step in modelling starburst hydrodynamics is the incorporation of the two-component gaseous structure with a dense disk and extended halo. A secondary shell forms in the halo after a primary shell distortion and hot gas blow-out of the galaxy disk. A careful analysis (Silich and Tenorio-Tagle, 1997) shows that under a wide range of parameters the hydrodynamical action of the gaseous halo could preserve mass venting from the galaxy into IGM and leave a total system bound.

Conclusion.

Comprehensive studies of the starburst ga-

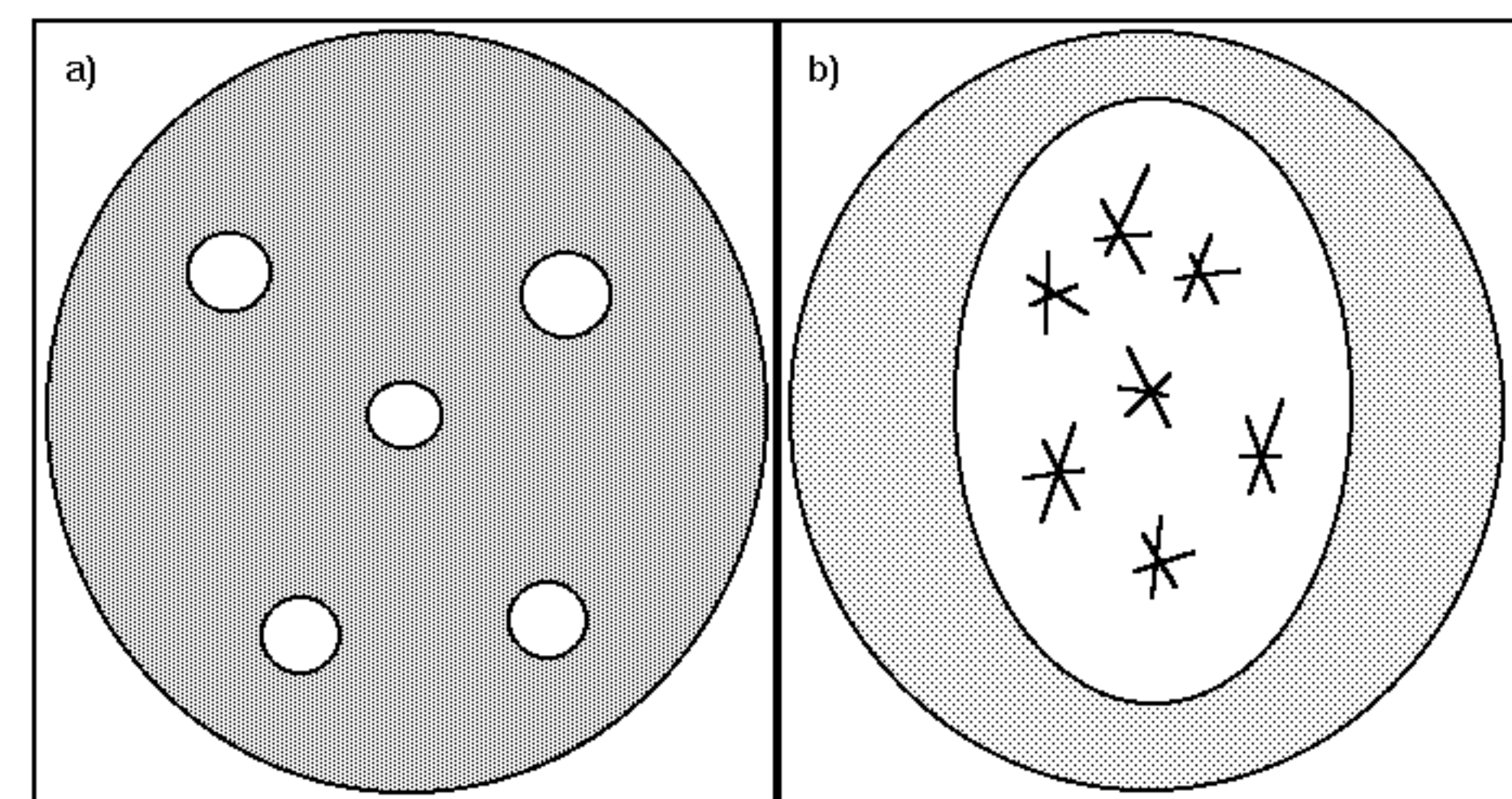


Figure 1: Two regimes for multiple SN explosions. a) Isolated remnants. b) Coherent shell.

laxies in visible, IR, X-ray and radio wave bands and numerical simulations undertaken during the last decade made a great progress in our understanding these intrigue puzzling objects. We understand now a current phase of the burst evolution, however can only guess of the principal mechanisms that initiate starburst activity and still cannot predict with a great degree of confidence the ultimate fate of the matter processed in a powerful starburst explosion.

Acknowledgements. The author would like to thank G. Tenorio-Tagle and R. Terlevich for many useful discussions of the starburst problem.

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CCD OBSERVATIONS OF DL DRA

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ABSTRACT. The CCD V-band photometry of variable Delta Sct-type star DL Dra have been carried out with aid of 0.5-m telescope-reflector. A CCD camera contains the virtual-phase CCD-chip ISDO15A. The light variation curves and power spectra are presented.

Key words: Variable stars, photometry, Delta Sct-type stars, CCD camera

DL Dra (HR 5492, HD 129798)- is the Delta Scuti-type star (F2IV) with non-radial pulsating. The observations by Guerrero at all. (1978) allow to find two sinusoidal components of period $P_1 = 0.0825$ and $P_2 = 0.0837$ days. The ratio between the two periods is $P_1/P_2 = 0.986$. A similar ratio was found by Shobrook and Stobie (1974) for 1 Mon (V474 Mon).

The CCD observations of DL Dra have been carried out during three nights of July-August 1997 with aid of 0.5-m reflector AZT-3 of Astronomical Observatory of Odessa State University. Our CCD-camera was created using the virtual-phase CCD ISDO15A produced by "Electron" (St. Petersburg, Russia). The camera has such parameters: 520×580 pixels (18×24 microns), sensitive area 9.4×13.9 mm, spectral band 0.2 - 1.0 micron. The Quantum Efficiency at different wavelengths is as follows: 15% at 0.2 microns, 28% at 0.4, 58% at 0.7 and 12% at 1 micron. The full well capacity is 220,000 e and dynamic range 6-7 mag. The readout noise is 10 e with high speed amplifier and 7 e with low noise amplifier. The camera has a gas- filled housing and thermoelectric (Peltier) cooler, which provides a temperature difference between the CCD and

that of the environment of about 40 C. An 10-grade analog-digital converter is used, a readout time 4 s (fast reading-clearing 1.5 s). An angular field of CCD with this telescope about 10 arcmin.

The observations obtained in band close to standart V photometric system. More 300 CCD-frames during three nights observations were measured and differential magnitudes in the sense variable minus comparison star were obtained. The times of the individual observations were reduced to the Sun's centre. The exposure time and the duty cycle were from 45 to 100 sec. The photometry have been made, using our program, which can perform CCD control, image processing and aperture photometry. The resulting observed light curves of DL Dra are shown in Fig.1-3, where the points denote the observed data. The comparison star (HD129798b) in the field are fainter than the variable, thus the variation light curve is noisier than own counts. The basic frequency 12.3416 c/d (0.08103^d) and amplitude 0.05^m from power spectra were found. The fit curve (solid line) were calculated using the Fourier mode of the program PERIOD (Breger, 1990).

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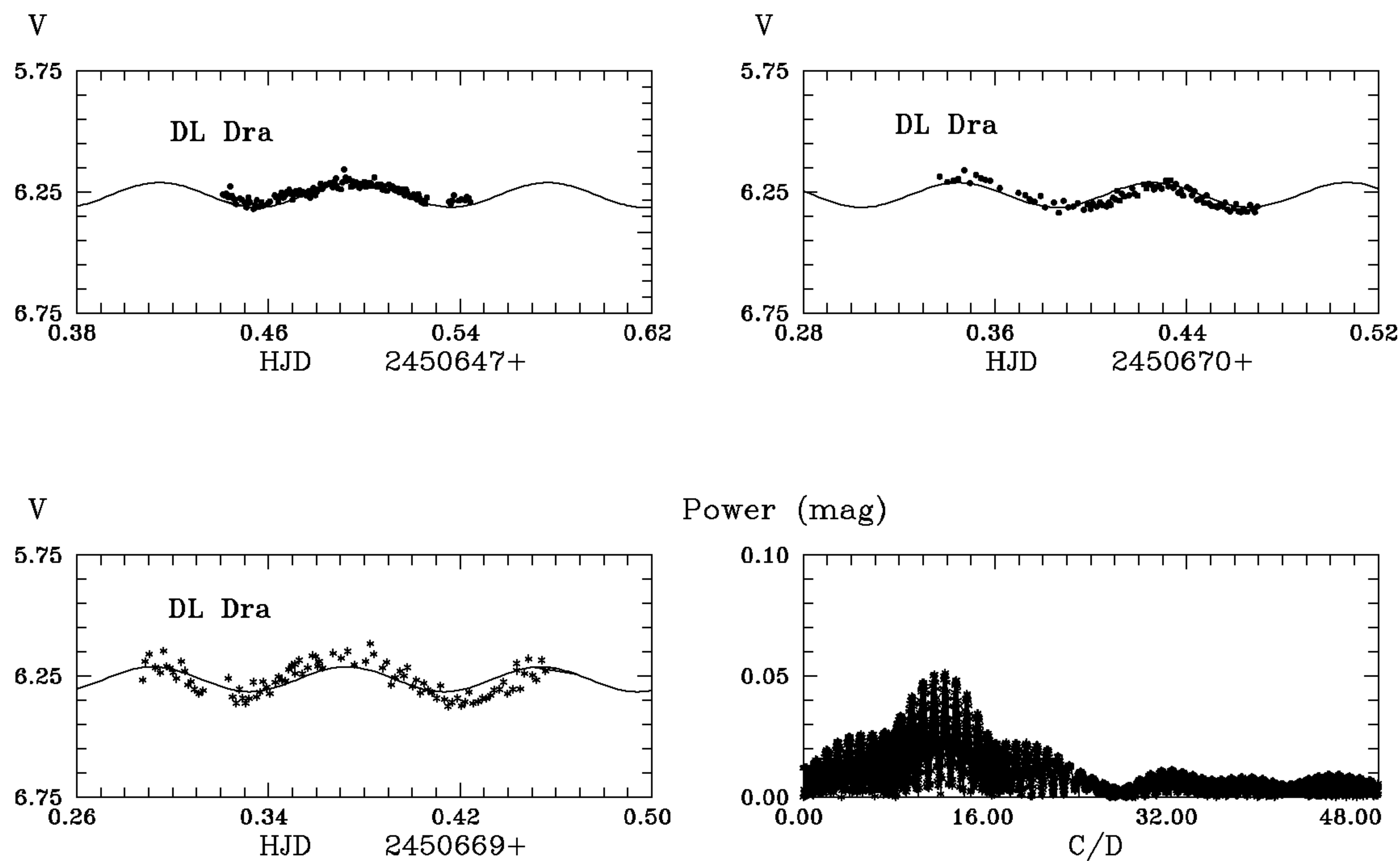


Figure 1-4. The V measurements and power spectra DL Dra. Solid lines represent the fit curve.

PHOTOMETRIC INVESTIGATION OF DR AND

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ABSTRACT. Based upon photographic observations obtained with a 48-cm reflector AZT-3 OAO, 236 estimates of the unique RR lyr – type star DR And have been derived. 6 moments of maximum light are listed, these being represented fairly enough by GCVS (1985) elements. The 3-rd order trigonometric polynomial fit corresponds to the period $P = 0^d.56318 \pm 0^d.00001$ (clos to the GCVS value), initial epoch HJD Max=2445121.466 $\pm$ 0^d.003, Max=12^m.06 $\pm$ 0^m.04, Min=13^m.14 $\pm$ 0^m.06. Light curve variations may be attributed to the Blazhko effect.

Key words: Stars: RR Lyrae–type stars: Individual: DR And.

For further investigation of secular variations of the period of the RR Lyr–type star DR And, we have obtained 236 photographic observations using the 48-cm reflector AZT-3, of the Astronomical Observatory of the Odessa State University within the interval JD 2444955 - 45353. The instrumental system is close to B ($\lambda_B = 4400 \text{ \AA}$), The magnitudes of the comparison stars were taken from the paper by Romanov et al. (1978).

The star was, in particular, investigated by Tsessevich (1957), who, based upon his own visual observations, was the first to suggest the Blazhko effect present in this star. Later on, the supposition was definitively confirmed.

To determine the acting value of the pulsational period, the phase light curve was fitted by a trigonometric polynomial with differential corrections to the period (Andronov, 1994). Various orders have been tested. The third order corresponds to the "false alarm probability" of only 10^{-12} . The corresponding best fit values are listed in the abstract. The estimated value of the period is very close to that of

Table 1. The list of maxima of DR And

Max JD hel	E	O-C	σ_T	mag
2444524.527	12971	+0.005		
2444884.355	13610	+0.001		
2444986.298	13791	+0.005	0.003	11.69
2444987.407	13793	+0.002		11.69
2444991.346	13800	+0.005	0.003	11.77
2445228.452	14221	+0.032	0.008	11.99

the GCVS.

To obtain the moments of individual maxima, the "running parabola" fit (Andronov, 1997) was used. The optimal value of the filter half-width Δt was found to be 0^d.025. Then the moments of extrema have been obtained by using this fit.

In Table 1 are given the moments of maximum obtained, the corresponding stellar magnitudes and the residuals O – C according to the elements of GCVS (Kholopov, 1985). The moments are well fitted by using these elements. The first two moments of maximum of DR And were obtained by Shakun L.I. (private communication) in the Astrophysical Observatory of the Kishinev University.

Acknowledgements. The authors are thankful to I.L.Andronov for reducing the data by using his programs and to L.I.Shakun for communicating two minima prior to publication.

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A POLARIMETRIC INVESTIGATION OF UNUSUAL STELLAR OBJECTS FROM THE BURAKAN SURVEYS. FIRST RESULTS.

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ABSTRACT We are present the first results for new polarimetry investigate the unusual stellar objects from Burakan Surveys.

Key words: Stars: polarimetry, white dwarfs, magnetic field.

We propose to investigate the nature of unusual stellar objects found in the First and Second Burakan Surveys with polarimetry of their optical flux. Polarimetry detects any preference in the orientation of the electromagnetic waves and provides concrete clues on the intrinsic emission mechanisms. Application of this technique in the past, to other surveys, has revealed new classes of stellar objects. Examples are magnetic cataclysmic binaries and Quasars without a gaseous envelope. The proposed observations will be conducted at the prime focus of the Russian 6-meter telescope of the Special Astrophysical Observatory (SAO) with polarimeters. Potentially this investigation could increase by one fifth to one quarter the known sample of magnetic cataclysmic binaries and magnetic white dwarf stars. As it happens with most surveys, there is a finite probability of discovering a completely new class of stellar object.

Even from the start of the Burakans Surveys (First Burakan Survey - Markarian, 1967 and Second Burakan Survey - Markarian, Lipovetsky, 1983) it was clear that many blue objects were not exactly galaxies. When a low resolution objective spectra could not be associated with any type of a stellar object known, or galaxy type, or Quasar, it was included in a list of unusual objects. Astronomers know that most advances in this discipline have started from

detailed studies of unusual objects.

The objective of this project is to investigate the degree of linear and circular polarization in the optical region of a significant sample of the unusual objects found in the Burakan Survey. Stellar radiation with polarization above 7observed flux or any time variations of the polarization are reliable indicators of intrinsic stellar effects: the polarization originates in the emission mechanisms taking place at or near the stellar surface. In some cataclysmic binaries, some white dwarf stars and most Quasars without a gaseous envelope =C4 also known as BL Lacertae objects or Blazars=C4 the emission mechanisms are tightly constrained by strong magnetic fields. In the magnetic regions of cataclysmic binaries or on the surface of white dwarf stars, radiation is dominated by cyclotron emission: electrons spiral in the magnetic fields, of several million to a few tens of million Gauss, with speeds clearly lower than the speed of light. In Blazars the observed radiation is consistent with synchrotron emission where electrons move at speeds comparable to the speed of light.

According to our current understanding of stellar evolution cataclysmic binaries and white dwarfs are near the end of stellar life. Models of cataclysmic variables consistent with the observed polarization variations disclose complicated magnetic and gravitational interactions involving transfer of matter between the components (Tapia, 1977; Remillard et al, 1991). Generally found in X-ray surveys, about 24 magnetic cataclysmic binaries are known and only 16 have been studied with moderate detail. Isolated magnetic white dwarfs are clearly rotating stars with a frozen dipo-

lar magnetic field. The observed variations of linear and circular polarization are caused by misalignment between the dipole and rotation axes (Bychkov et al.,1991). There are more than 20 isolated magnetic white dwarfs known.

So far we observed 3 objects only for this programm. These objects have unusual spectra and were preliminarily attributed to unusual white dwarfs. A linear polarization of emission was not detected for the object SBS1619+606. The second object SBS1622+587 showed the linear polarization in V filter of Jonson's photometrical system, and the third object SBS1657+584 showed the polarization in the violet side of spectrum (U filter of Jonson's photometrical system). See the table. The objects have been polarimetrically investigated for the first time. The obtained results will help to explain the unusual shape of the spectrum that could be a convincing argument in favor of strong magnetic fields on the surface of these objects. This programm only started now and we have a small number of observational results, but it is seen now that the main direction of research has been chosen correctly, since for two of three objects a positive result has been obtained - the polarization of their radiation has been found.

Acknowledgements. This material is based upon work supported by the U.S. Civilian Research and Development Foundation under Award No.RP2-151/96.

Table 1:

JD	P	σ (P)	θ	Filter	Exp. min.
2450+					
SBS 1619+606					
634.254	.361	.357	133.5	R	3
SBS 1622+587					
634.294	1.031	.997	51.5	U	2
634.297	.474	.401	112.6	B	3
634.302	1.642	.279	37.9	V	3
SBS 1657+584					
634.267	4.366	1.084	158.2	U	3
634.270	.245	.410	150.0	B	2
634.274	.281	.129	120.0	V	3
634.279	.899	.313	42.1	R	3
634.282	.411	.400	118.0	I	3

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NEWS FROM MT. DUSHAK-EREK DAG STATION OF ODESSA ASTRONOMICAL OBSERVATORY

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ABSTRACT. This report continues the series of articles about observations at the Mt. Dushak-Erekdag station of Astronomical Observatory, Odessa State University in Turkmenistan. A 0.8 m telescope with the dual-channel PMT photometer is installed at the station. From 1993 to 1997 years the photometer participated in 6 astero-seismological campaigns and in some international programs. The instrumentation is modernized and quality of observations is improved. The following scientific researches are carried out at the station: α (rapidly oscillating) Ap , δ Scuti and λ Booti stars, variability in the spots of cool stars, close binary systems, etc. Besides the station participated in the programs of asteroids' security and investigations of Solar system by means of photometric observations of eclipses and occultations of large planets' satellites. This work became possible thanks to cooperation with colleagues from different countries.

Key words: Observatories, instrumentation

In volume 7 of these "Publications" the first report (Dorokhov et al., 1994) about observations from Mt. Dushak-Erekdag station of Astronomical Observatory, Odessa State University, appeared. It was based on 1992 year's observations, mainly, so this communication may be considered as the 5-year report of observational activity, events and results of the station. From 1993 to 1997 years 5 prolonged (2 - 4 months') expedition were realized to the station in Turkmenistan. Because of the

difficulties in financial support, the participation in international programs and astero-seismological campaigns was the main work of the station. It should be reminded that the location of the Mt. Dushak-Erekdag Observatory ($\phi = +37^\circ 56'$ N, $\delta = 3^h 52^m$ E) is very suitable for cooperation with existing astero-seismological networks, such as DSN (Delta Scuti Network) or WET (Whole Earth Telescope).

During 1993-1997 the station took part in the next multisite photometric campaigns:

- VW Ari (δ Scuti star) with STEPPI (STellar PHotometry International) network campaign in October 1993 (see Dorokhova et al., 1998);
- ET And, coordinated by W.W.Weiss, in September 1994;
- TT Ari (cataclysmic variable), organized by I.L.Andronov, in October-November 1994 (see, for example, Andronov et al., 1995);
- $\theta 2$ Tau (δ Scuti star), organized by M.Breger, in November-December 1994;
- BH Psc (δ Scuti star), organized by E.Poretti, in October 1995;
- 4 CVn (γ Dor star), coordinated by M.Breger, from the beginning of March to the end of May 1997.

The participation in international campaigns is very important and useful (see, for example, Butler, 1994). This work at the forward level of scientific investigations in the world gives an opportunity to take part in the projects of the leading specialists in the corresponding branches of astronomy, directly acquaint ourselves with the work in observatories of other countries, to compare quality of observations, to

gain an experience in uniting of the data from different light detectors.

At the same time such work demands selflessness of an observer who has to refuse from own observational plans, permanent readiness of equipment and high accuracy of observations. That is the necessity of permanent modernization and improvement of the instrumentation with an excellent chance to control.

All observations from the Mt. Dushak-Erekdag were performed with a dual-channel PMT photometer (Dorokhov & Dorokhova, 1994), mounted on 0.8 m telescope. Last year and this one we prepared and installed a new interface and software for the suitable managing by the photometer and data viewing. It was difficult to do this during short sojourn at the station, and the base work was done in the laboratories of Odessa Observatory and Majaky station.

As a result photometer's characteristics were improved: the integration times may be used from 1 msec. to essential value with a dead time 1 msec. In one-channel mode an accuracy of observations is reached to $0^m.001$ for stars to 6^m and $0^m.005$ mmag for stars of 10^m - 13^m in B, V, R filters. In dual-channel mode an accuracy of observations is $0^m.001$ - $0^m.002$ for integration time in order 10 sec.

A problem was with the correction of the channels' drive (usually less than 3% during a night) which was done before this year by using the comparison star's observations through the primary channel and the secondary one in turn. Such channel calibrations took a lot of time and brought low accuracy (see Dorokhova et al., 1998). A correction by using the observations of the sky background in both channels as it realized in some type of multichannel photometers involves a large uncertainties in resulting data, too, from the low counts. This year we have constructed and installed the inside calibration system. The light from a single optical diode is passed simultaneously to 2 photomultipliers by using fiber light guides. Switching from working mode of the photometer to calibrations is made automatically. The time taking for channel reduction is about 2 min., an accuracy of the calibration coefficient

is about 0.02 %, that inserts the error less than $0.^m0002$ in resulting data.

Dual channel mode is useful not only for improvement of accuracy: many times we could test and verify the parameters of low amplitudes' variability comparing the data from both independent channels. Particularly dual channel observations were to the point when we participated in the Program Russian Ministry of Science "Monitoring of Unique Astrophysical Objects". At the night 28/29 Oct. 1995 the great unusual outburst of X-ray pulsar A0535+26 was detected (see Dorokhov & Dorokhova, 1996b). The outburst consisted of a great number of transitory individual pulses, an amplitude of single pulse at the maximum of the outburst's intensity amounted to $1^m.73$. The specialists were in doubt to explain the phenomena and proposed its instrumental origin. But the dual channel observations were satisfied very much: a comparison star was observed permanently in the second channel and twice for 5-7 min in the first channel during the event with a mean square error about $0.^m0005$ due to exclusively stable sky transparency at that night.

Separately it should be mentioned a split prism which may be adapted for simultaneous observations of the star in different spectral regions. We used the prism for roAp stars observations in B and R filters (Dorokhov & Dorokhova, 1996a) and for research of the behavior of TiO spots in the red stars (Komarov et al., 1998) with a narrow band interferometric filter centered on TiO-band (Johnson V filter was in the second channel). We planned observations with using series of narrow band interferometric filters. Unfortunately this project has not been realized yet because of financial difficulties.

The dual-channel mode is very suitable, but in the cases, when comparison star is outside the field of view, the well-known three-star mode (Breger & Handler, 1993) are adapted for accurate observations. Now we have just begun to construct the device for automatic moving of the telescope on three-star program. The cycle of observations Sb-C1-V-C2-Sb may be fulfilled in 5 minutes.

This way the general trends of scientific researches came into view:

- the searches and investigations of roAp (rapidly oscillating) Ap stars (Dorokhova, 1998);
- variability of low amplitudes' δ Scuti and λ Booti stars (Dorokhova & Dorokhov, 1996; Dorokhova et al., 1998);
- close binary systems (Andronov et al., 1995; Dorokhov & Dorokhova, 1996b);
- variability in the spots of cool stars (Komarov et al., 1996).

Besides the station participated and further can participate in international program of asteroids' security and in new investigations of Solar system by means of photometric observations of eclipses and occultations of large planets' satellites (see, Emelianov, 1997).

An important aspect of cooperation with Turkmenian colleagues should be noted. A mutual assistance is absolutely valuable in hard economical situation in our countries.

Unfortunately the station does not work a significant part of the year due to lack of state financial support. We use any opportunity to continue observations and we are ready to cooperate with other investigators. Welcome to the Mt. Dushak-Erekdag!

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FIRST OBSERVATION AT THE TÜBİTAK TURKISH NATIONAL OBSERVATORY

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ABSTRACT. The B, V and R light curves of well-known close binary W UMa were obtained at the newly constructed TÜBİTAK Turkish National Observatory which located approximately 50 kilometers north of Antalya city. 40 cm telescope donated by Utrecht University was used during the observations. Comparison and check star's observations versus air mass and Check minus Comparison values are presented.

Key words: Stars: binaries: close-stars: individual (W UMa) - stars: variable

Introduction

Observation of the well-known close binary system W UMa was made at the TÜBİTAK Turkish National Observatory having the short name TUG. These observation is very important for the Turkish astronomers. Because this is the first observation at the first National Observatory of Turkey which established by TÜBİTAK (Scientific and Technical Research Council of Turkey). Observatory site is at the Bakırlitepe summit which is one of the highest (2547 m.) summits of the Taurus mountains. Latitude is $36^{\circ} 51'$ North, longitude is $30^{\circ} 20'$ East. Time Zone is +2 hours. Astronomical seeing is less than 5 arcseconds. The site is located at the north of Antalya city and approximately 50 kilometers away from it. The official opening of the observatory on September 6th, 1997 but the photoelectric observations are going on since the first observation. Every kind of celestial body –members of the solar system, stars, clusters, intraplanar material, nebulae, galaxies– will be able to be observed photometrically and spectroscopically

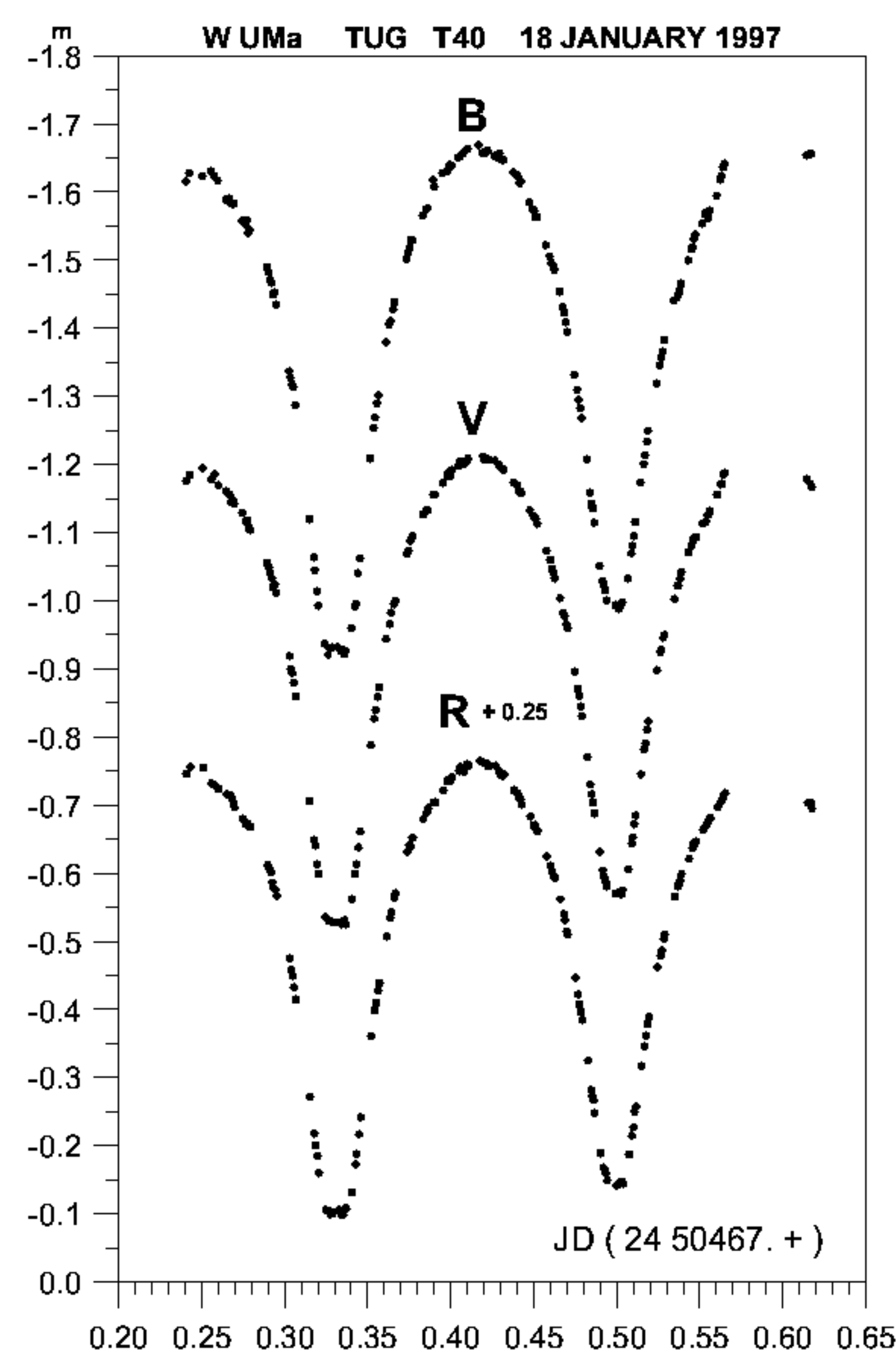


Figure 1: B, V and R light curves of W UMa obtained at the TÜBİTAK Turkish National Observatory.

at optic wavelengths in near future at the observatory. Still constructing 1.5 m. telescope of the observatory is a joint project between IKI RAN (Space Research Institute of the Russian Academy of Sciences), EAO (Engelhardt Astronomical Observatory of Tatarstan) and TÜBİTAK. We hope to obtain the first light with this telescope in the second half of 1998.

Extinction Coefficient	Comparison	Check
k (B)	0.0742 ± 0.0038	0.0746 ± 0.0028
k (V)	0.1175 ± 0.0019	0.1341 ± 0.0052
k (R)	0.2072 ± 0.0036	0.1424 ± 0.0201

Table 1: Atmospheric extinction coefficients for each passband for comparison and check stars.

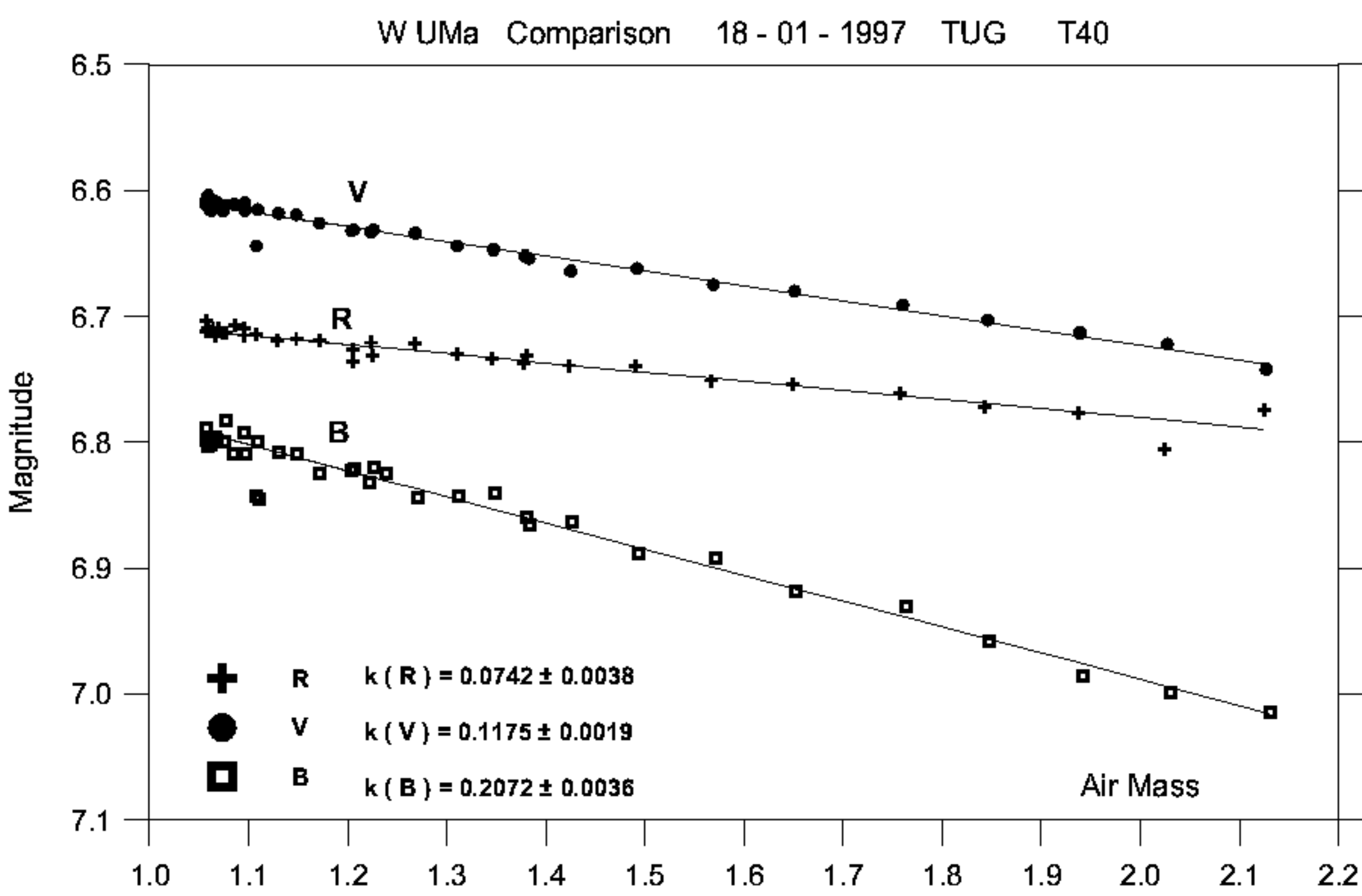


Figure 2: B, V and R observations of the comparison star.

Observations

Observations of W UMa (BD +56°1400) were recorded using SSP5A photometry provided by Ankara University Observatory. B, V and R standard filters were used during the observations. BD +56°1399 (Hamzaoglu et al., 1982) and BD +56°1397 were monitored as comparison and check stars, respectively. The differential magnitudes in the sense variable minus comparison were corrected for atmospheric extinction and the times of the individual observations were reduced to the Sun's center. The standard deviations of single differential observation do not exceed 0.005 mag in each passband. The light curves of the system are shown in Fig. 1. R light curve is shifted up 0.25 mag in order to show all three light curves in one figure. In Fig. 2, observations of the comparison star are shown versus air mass. Atmospheric extinction coefficients for each passband were calculated. These values were calculated using only the observations after meridian and used for whole observations. Because the number of observational points before meridian is very less. Magnitude scale is arbitrary in figure.

In Fig. 3, observations of the check star are given versus air mass. Atmospheric extinction coefficients for each passband were also calculated from this observations. These values are very similar to the values obtained from the comparison star.

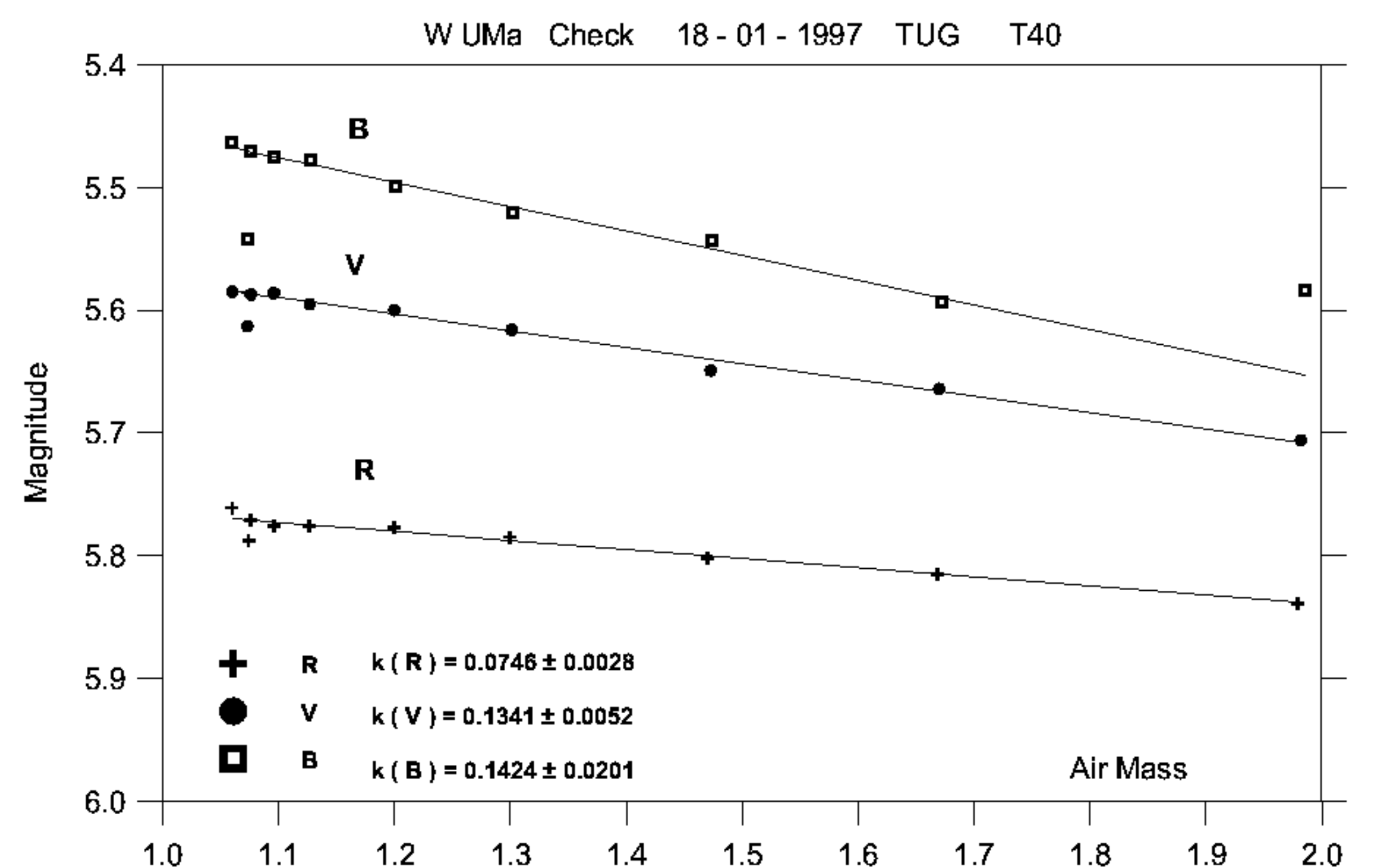


Figure 3: B, V and R observations of the check star.

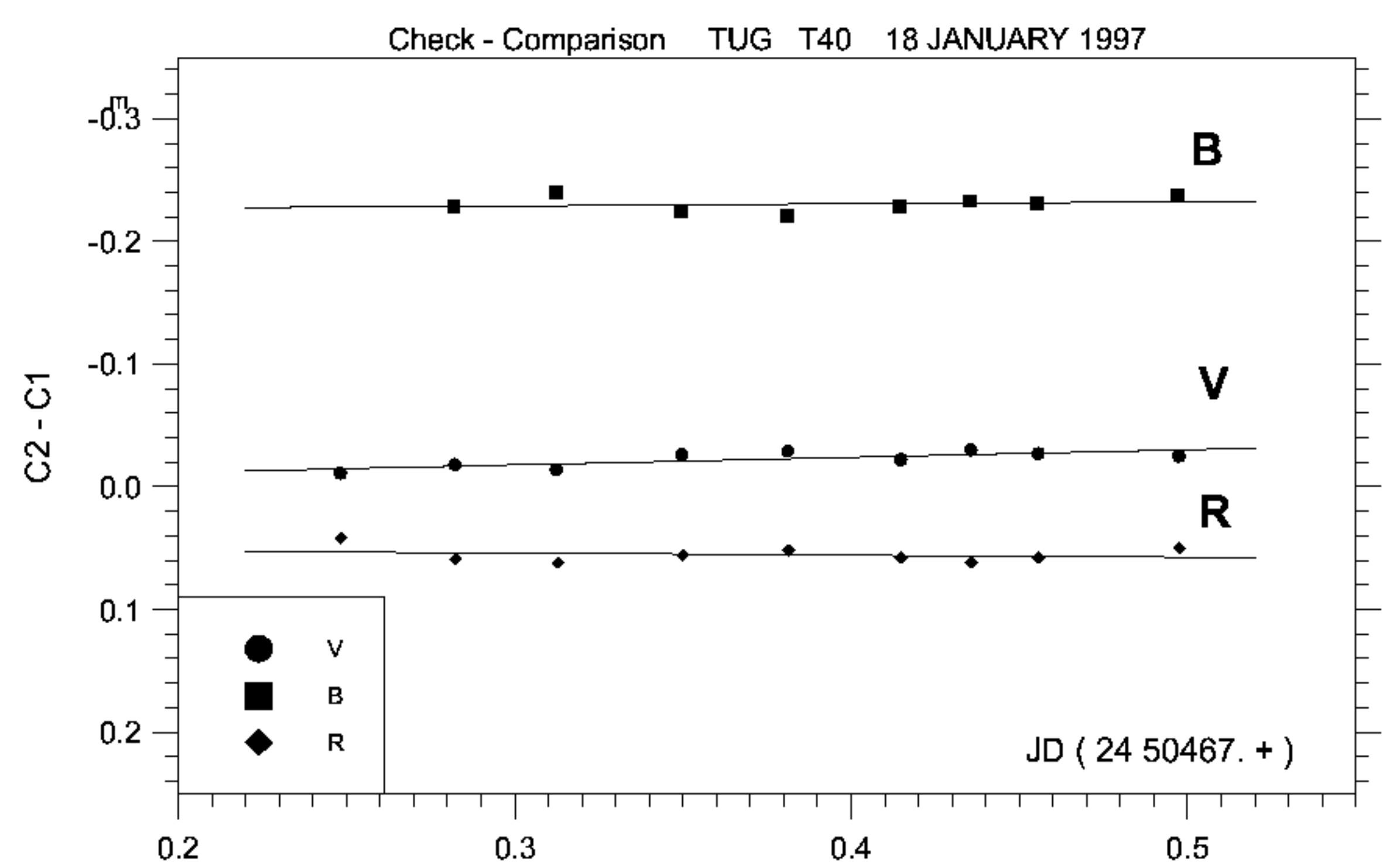


Figure 4: Comparison - Check curve.

In Fig. 4, check minus comparison values versus fraction of day are shown. In figure, linear fits to observations for each passband are also shown in order to see the deviations clearly. Maximum deviation in the figure does not exceed 0.005 mag.

Acknowledgments. The authors are thankful to the Director of Ankara University Observatory who provide the SSP5A photometer for the first observation.

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SOME RESULTS OF TEN YEAR OPERATION OF THE AUTOMATIC MEASURING COMPLEXES PARSEC

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ABSTRACT. The brief description of the automatic measuring complexes PARSEC and some results of their ten years operation have been repoted in the paper.

Key words: Instrumentation

In 1986 four automatic measuring complex (AMC) PARSEC (Programming Automatic Radial-Scaning Coordinatometers) have been installed at the observatories of Golosiiv, Pulkovo, Nikolaev and Sternberg Institute in Moscow. The main purpose of their development was the determination of the precise coordinates of images on photographic glass plates with simultaneous precise photometry. The basic assignment of the complexes was the maintenance of the measurements of large files of plates for the creation of survey catalogues of positions, proper motions and magnitudes of stars.

The observational projects which requiered the automatic measuring machines for measurements about twenty thousands plates had been in progress to that time in seven observatories of the fomer USSR (Nesterov et al.1990). The wide-angle astrographs have being used for realisation of these projects were installed in the places with astroclimatic conditions far from an ideal ones. The plates had been available for observations (ORWO ZU-21) were not of high quality. In a consequence of that reasons the astronegatives obtained were of very wide range of density of sky background and of image contrast and quality. Having such plate material was necessary to ensure the pre-

cise automatic measurements of positions and magnitudes of many thousands plates with minimum expenses of time and resources.

All that has defined the strategy and ideology of being created automatic measuring complexes and have been embodied in the method of radial-angular scanning (Sergeev et al.1984). At this method the image processing is carried out lagely by fast optical-mechanic equipment with hardware integration of radial densities of the image. The software realize the control and management of the prosess. Such method does not require enormous computer resources. The basic units of AMC PARSEC are as follows. The carriage with a plate is moved by system of positioning with the independent movements in two perpendicular directions. The readout of coordinate of the carriage is realised by amplitude-phase-sine-cosine interpolation of signals from raster gauges. Light from standard halogen lamp, passing through a plate, is divided on two flows. One of them transports the image of measuring area of a plate to the screen of the operator, other passes through the scanning system and is registered by means of the photoelectronic multiplier. The hardware and micro-computer carry out the control and management of process of measurements. The PC IBM-486, connected in a line with PARSEC, provides the data interchange (the input files of preliminary coordinates and output files with results of measurements) and provides the intermediate storage of the data.

The software of AMC PARSEC has the modular structure and provides the flexibility of

functioning of the complex. That gives the opportunity to develop various measuring modes. At the present time AMC PARSEC has three basic modes of measurements.

1. *Fully Automatic Measuring Mode.* Carries out an automatic measurements of coordinates and effective diameters of images according to the initial list of preliminary coordinates.

2. *Automatic Installation and Registration Mode.* Carries out an automatic installation of the image in a point given by the preliminary coordinates, visual centering of the image and automatic registration of measured coordinates. The mode can be used for measurements of objects with complex form (lunar craters, for example).

3. *Automatic Registration Mode.* Allows to form files of preliminary coordinates through manual installation of the preselected images with help of the control panel and automatic registration of their coordinates.

The speed of measurements of AMC PARSEC are from 500 to 1200 images per hour. It depends on the accuracy of the input preliminary coordinates and on the density of stars on a plate.

The accuracy of measurements with AMC PARSEC was defined by special researches (Bystrov et al.1989, Dick et al. 1989, Ivanov et al.1988, Ivanov et al.1990) The plates have been measured with PARSEC for hardly more than ten years of operation were obtained with various telescopes. As already was mentioned, the quality of the plates and images on them varied over a wide range. The results of the researches testified, that the method of processing of the images, realized in PARSEC, provides measurements with acceptable accuracy of very dark plates with density of a background up to 1.5D, and of the images with very low contrast. The repeatability of the position determination extremely rare exceeds 2mkm even for the most dark plates with very sharpless images. For the images of weak objects close to plate limit some kind of magnitude error may arise which can be completely eliminated by measurement of plates in opposite direction.

For some objective and subjective reasons AMC PARSEC at Pulkovo and Nikolaev ob-

servatories are not functioning with full possibility, but the observatory of Golosiiv and Sternberg Institute carry out the measurements of their survey plates. At present Golosiiv almost finished the measurements of the Kiev part FON-project plates. The accuracy of FON positions and proper motions of star from the measurements of the onefold coverage plates is estimated to be 0.35 arcsec and 0.006 arcsec/yr, respectively.

The measurements of the plates containing the images of clusters which have photoelectric standards have been carried out for estimation of photometric properties of PARSEC (Voroshilov et al.1992). The results of measurements are presented in Table 1. The observation on two telescopes (60 and 200 inch refractors) were used to develop NGC-188 standard. The PARSEC measurements showed the systematic difference of two rows of observations. For this reason the comparison on all 58 stars of the standard has given greater error, then comparison on group of stars, photometric parameters of which have been received with one telescope. Probably, it is impossible to receive the best result within the photographic photometry method for a single plate. Smaller almost on the order the r.m.s. error of one measurement, determined on five series, speaks about good tool opportunities of PARSEC as photometer. This conclusion was independently confirmed at creation of the B-magnitude catalogue with the purpose of search of chemically peculiar star clusters (Marchenko et al. 1991, Marchenko et al. 1994). The material for measurements were the plate of Double Wideangle Astrograph with very different quality. But the applied philosophy of measurement had allowed to receive very good results (Table 2).

The results of using of automatic measuring complexes PARSEC for various astronomical investigations obviously testify them as a very effective system capable to determine the precise coordinates of star-similar images on photographic glass plates with simultaneous precise photometry. They can be used for measurements of plates of various quality at fulfillment of a wide range of investigations both astrometry and astrophysics. Applications of

Table 1. Estimation of photometric properties of the PARSEC							
Cluster	Tele- scope	Color system	Plate	Magnitude range	NS	Unit weight r.m.s.	Repeata- bility
NGC-188	STB	U	ZU-21	8 ^m 6 -17 ^m 2	58	0 ^m .133	
				8.6 -15.0	29	0.059	
NGC-6913	AMT	V	Codak	8.59-17.23	29	0.070	0.014
NS - the number of the cluster stars used for accuracy estimations							

Table 2. The accuracy of B-magnitude catalogue				
Magnitude range	Internal convergence	NS	External error	NS
6 ^m - 7 ^m	0 ^m 08	13	-	
7 - 8	0.08	17	0 ^m 09	3
8 - 9	0.07	39	0.15	6
9 - 10	0.05	159	0.11	20
10 - 11	0.05	458	0.08	47
11 - 12	0.05	694	0.14	22
beyond 12	0.06	77	-	

PARSEC in biology, medicine, geodesy and optical researches are also possible. The original systems of readout of coordinates - Interpolators have been realized in PARSEC can be used in developments of precise readout systems for wide range of astronomy purposes as well as in optical technologies, geodetic devices, mechanical engineering.

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"TIME SERIES WORKSHOP" - OBSERVATIONS DATA PROCESSING TOOL

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ABSTRACT. The new tool for mathematical and visual processing of time series is represented. The program "Time Series WorkShop" (TSW) is specialized for processing visual observations of variable stars. An open structure of the allows to apply any old and new mathematical methods for searching any parameters of variability. The program also allows to visualize the time series and any calculation results (periodograms, histograms, light curves and their smoothing curves) in a camera-ready form. The following mathematical methods are realized: the periodogram analysis with "prewhitening", the method of "running parabolae", some methods of correction of observational series, including that taking into account the differences of the instrumental systems of individual observers. The possibility of exporting images into standard graphic formats and printing is specified. The program Time Series WorkShop has passed test trials at processing of visual observations of semiregular variable stars on the AFOEV and VSOLJ databases. TSW, like any other program product, will be developed by adding new mathematical methods and visualization improvement.

Key words: Time series analysis; Stars: semiregular, S Cam

Introduction.

The creation of the program "Time Series WorkShop" (TSW) is dictated by necessity to process large arrays of variable stars observations. "Time Series WorkShop" is oriented on mathematical and statistical handling of time series, and also, that on our sight is not less important, the high-quality graphic represen-

tation of outcomes. One of the tasks of TSW is the reduction of time expended on design of outcomes of evaluations. However, TSW is also a mathematical tool, in which the modern methods of searching parameters of variable stars oscillations are realized. The use of visual programming Borland DELPHI 3 in 32-bit operational system WINDOWS 95, and of the object-oriented programming language Object Pascal has allowed to obtain new possibilities in the field of time series processing.

The program contains algorithms of reading the data, including the special formats of the international databases of observations AFOEV and VSOLJ, which are accessible via Internet. The program automatically determines (by file extension) with what database it works, allows to merge databases in one and to save in a customary format - (columns XY) with the observer name indication. Unfortunately, VSOLJ database sometimes have error expressions (for example, a date 30.02.97), which are interpreted as a format read error and they cannot be used at processing.

"Time Series WorkShop" possibilities

Mathematical part of the TSW contains the following methods:

- Method of "running parabolae" (Andronov, 1997)
- Determination of the optimal value of filter half-width for the "running parabolae" method (Andronov, 1997).
- "O-C cutoff" correction observation data, based on "running parabolae" method;
- "Systematic differences of the instrumental systems of individual observers" correction,

based on "running parabolae" method (Chinarova, 1998)

- Periodogram analysis with precise period determination by using the method of differential corrections (Andronov, 1994).

Visualization part of the TSW:

- Light curve visualization.
- Periodogram building visualization.
- "Signal/noise" ratio building visualization.
- Several histogram visualization.

Additional functions of the TSW:

- Translation of the Julian date into the Gregorian date and backward.
- Reading data in the AFOEV and VSOLJ formats.
- Merge databases.
- Automatic sorting and filtering data files.

Smoothing by a method of "running parabolae"

The method of "running parabolae" was described by Andronov (1997). The program allows to compute a smoothing curve for processed series for a given filter half-width and filter type. There are four types of filter: 1 , $(1 - z^2)^2$, $1 - |z|$, $\sin(2\pi z)/2\pi z$. Usually we apply the second type of filter.

Determination of the optimal value of filter half-width

For approximation by a method of "running parabolae" it is necessary to calculate an optimal half-width of a filter. In the TSW program is being computed so-called "signal/noise" ratio (Andronov, 1997) or the ratio of mean-squared deviation of a smoothed value from the average to a mean accuracy of a smoothed value. The optimal half-width of a filter for approximation is determined as that corresponding to a maximum value of a "signal/noise" ratio. As the process of computation of "S/N" is rather long, the program allows visual monitoring. Each computed value immediately is deduced on the graph. It is possible to obtain more precise value of a maximum by computing values in the vicinities of maximum with a smaller step. In a realization of a method there are following possibilities: to save outcomes in

a file, to print the graph at any moment of evaluation process, to view and to continue the interrupted evaluations, to show progress of an evaluation by a visualization on the graph of each already computed point, to study in more detail any part of the graph chosen by the "mouse".

Filtration of data and correction for an individual system of the observer

In the TSW some methods of a correction of data are represented.

A "manual correction" - possibility of deleting "visually bad" points manually. Thus the light curve usually becomes more suitable both for visual and mathematical processing. To check the process it is possible to look through a histogram of distribution of signal values.

"O - C Cut off" correction of data using a method of "running parabolae". The essence of such correction consists of the following: the deviations of the observed values of a signal "O" from the smoothed "C" are calculated, the histogram of distribution of "O - C" is shown. Then a conventional maximum value Δm of "O - C" is chosen, and the data with larger deviations are deleted.

Systematic differences of the instrumental systems of individual observers are determined by averaging "O - C" for each author. For a reduction, these mean shifts are deleted from the original observations, if the ratio of mean value of "O - C" for the given author to the standard error of it is larger than 3 (3σ criterion). The individual observations are removed, if $|(O - C) - \langle O - C \rangle| > \Delta m$. The updated series can again be smoothed by the method of "running parabolae" and used for the time series analysis.

Computation of periodograms and "prewhitening"

The periodogram analysis is realized by using the least-squares algorithm described by Andronov (1994) used in his Fortran code FOUR-1. The test-function is determined as $S(f) = \sigma_C^2 / \sigma_O^2 = 1 - \sigma_{O-C}^2 / \sigma_O^2$. Here σ_O is a mean-squared deviation of observations "O" from mean. The index "C" corresponds to cal-

culated values and " $O - C$ " to the deviations of observed values from the calculated ones.

The initial frequency is offered automatically with possibility of consequent editing at a value of $f_{begin} = 1/(t_n - t_1)$. The frequency step is shown for information, and varies at any modification of a number of frequencies (Points Count) or of a phase step $\Delta\phi$ in corresponding windows. Thus $\Delta f = \Delta\phi/(t_n - t_1)$.

Usually the number of trial frequencies is about 4000-8000. Also it is possible to process the periodogram analysis with a "prewhitening" - subtraction of the best harmonic fit from the data, recomputation of the periodogram for the residuals, subtraction of a new best fit sine etc (see Wehlau and Leung (1964) for details). In this case one should to set the desired number of "prewhitening" cycles. It is possible to monitor the process of an evaluation and construction of a periodogram immediately. Thus it is possible (without interrupting the process) to view interesting sites of a periodogram and make any conclusions, "zoom in" and "zoom out" the graph. After evaluations it is possible to save picture of a periodogram in a graphic format Windows Bit-Map (bmp), Windows MetaFile (wmf) or Enhanced MetaFile (emf) and print. Example of the periodogram is shown in Fig.1.

Preparation of the light curves for visualization

The main function of the TSW is the automatic visualization of the light curve of variable star. The default type is shown in fig.2. Picture may be printed in any printer resolution or may be saved in a Windows BitMap (bmp) format.

The program allows to set up parameters of visualization: division of a light curve into parts of a total number determined by user. This possibility is intended for more detailed visual representation of a light curve. Also may be set the distance between the graphs (in mag), depth of a colour gamma, vertical (m) and horizontal (JD) axes of the graph. Set up is possible for titles of axes with a choice of the necessary font and its size, choice of a number of markers on axes, their fonts and sizes, auto-

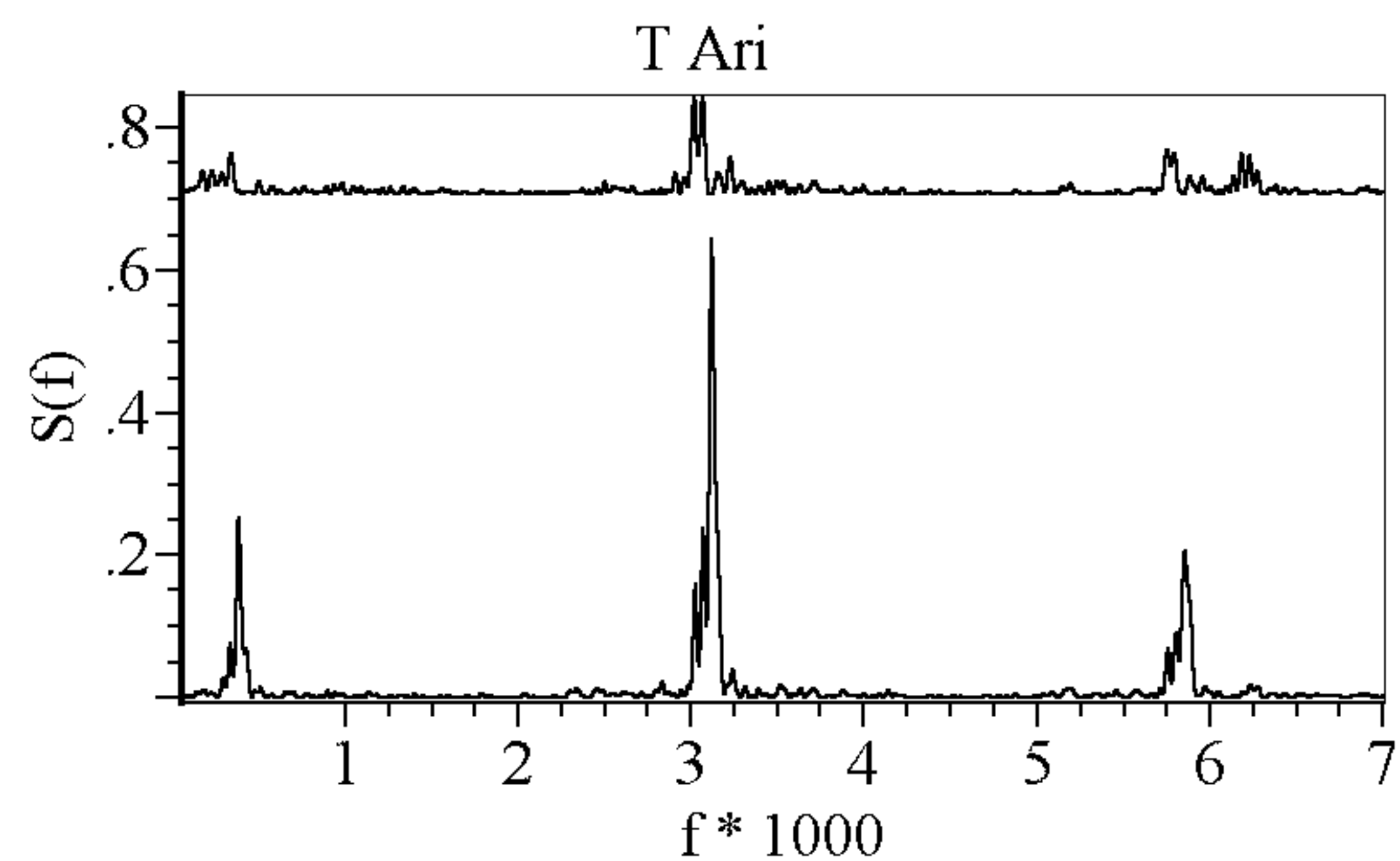


Fig.1. The periodogram representation in the TSW for original and "prewhitened" data.

matic or manual breakdown of axes, and also a mantissa of markers. The program has a system of reports generated after calculation of all basic operations. The report can be viewed and saved in a file. Besides, TSW has auxiliary functions, for example, a translation of Julian date into Gregorian date and backward.

For a development of the program that fact was taken into account, that it should be simple and convenient in use and thus to make evaluations fastest. Besides the user should have a possibility to inspect the process and, if it is necessary, to interrupt evaluations without losing anything from already made. Therefore, the possibility of interruption of the process at any time is stipulated. Each realized method of evaluations has a "set up" window for setting parameters of the process.

The program "Time Series WorkShop" was tested at processing of observations of semi-regular variable stars from the AFOEV and VSOLJ databases. The program is ready for use now and will be improved.

Acknowledgements. The author is thankful to I.L.Andronov for supervision of the work and to O.V.Tsimaenko for helpful comments.

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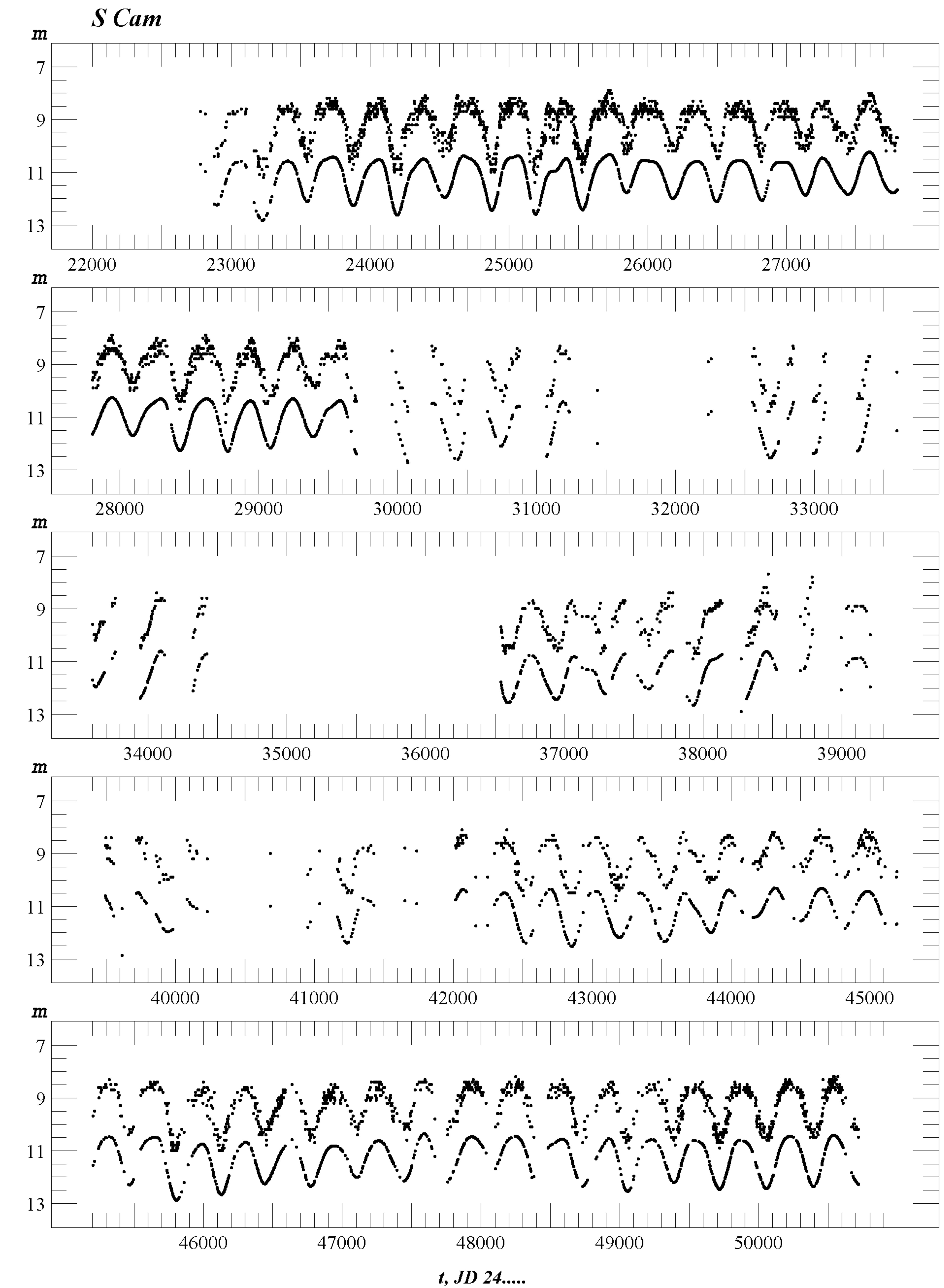


Fig.2. The light curve representation in the TSW. *Up*: original data, *bottom* "running parabolae" fit with an optimal value of the filter half-width Δt . The data are used from the AFOEV (<ftp://cdsarc.u-strasbg.fr/pub/afoev>) and VSOLJ (www.kusastro.kyoto-u.ac.jp) databases.

ON CONDUCTION OF THE ORBITS OF ARTIFICIAL SATELLITES

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ABSTRACT. Two-channel photoelectric photometer was made in 1971 in the Uzhgorod State University, which was intended for calculating of brightness of low-orbital satellites. And from that time the observations for satellites in the integral light were regularly conducted on it.

In 1989 new two-channel photoelectric photometer, working in the system B,V Johnson-Morgan, was made.

Large experimental material was collected, the light-curves of 154 satellites during about 2500 observations were obtained. In particular, by 790 observations of 46 satellites, the periods of visible change of the brightness of the objects were calculated. The maximal accuracy of the determination of the period was 0.001-0.003 second for the object 86061.

The light-curves of satellites were use for solutions of different tasks. They may be given consumers who are interested.

Key words: Artificial satellites, photoelectric photometer, light curve, visible period of rotation

Having results of electrophotometry of artificial celestial bodies (ACB) one can solve the task of applied and fundamental characters (Venkateswaran et al., 1962; Emmons et al., 1967; Vanderburgh and Kissell, 1971; Megue et al., 1971; Kissell, 1974, Vovchik and Fedoriv R.F., 1976).

Taking into account the perspective of the method, employees of the astronomical laboratory of Odessa University and of the laboratory of cosmic studies (LCS) of Uzhgorod University in 1971 worked out and produced a

two-channel photometer for the photometry of low perigee satellites (Bratijchuk et al., 1974). The electrophotometer, that works in the regime of intensifying direct current has been a reliable device for obtaining photometric information for almost ten years.

A complete set of devices for ensuring electrophotometric observations of the ACB in the regime of photon counting was worked out at the LCS in 1980. The complex allows to change the time of signal storage from 10 sec to 0.04 sec (Bratijchuk et al., 1982). Both electrophotometers have as then basis an objective-glass MTO-1000 ($F=1m$, $Def=8.6cm$). The penetrating capacity of both electrophotometers is 9m. The error of measuring the brightness of bright objects ($2m - 4m$) is 0.03m, of weak ($8m - 9m$) is 0.1m - 0.2m. With the help of these electrophotometers about to thousand of qualitative light curves for about one hundred different satellites have been obtained.

A two-color B,V electrophotometer was worked out and put into operation in the LCS in 1989. This new device was built upon the basis of the operation electrophotometer working in the pulse regime. Such an approach allowed to transfer from measurements in the integral light to measurements in the B,V bands depending on the tasks. It is guaranteed with the peculiarities of the optic-mechanical construction of the device. The bands of passing B,V are realized with glass light filters. The effective lengths of the instrumental system of the colorimeter are close to the standard Johnson-Morgan system ($\lambda_{ef,B}=4337 \text{ \AA}$, $\delta\lambda=875 \text{ \AA}$; $\lambda_{ef,V}=5504 \text{ \AA}$, $\delta\lambda=750 \text{ \AA}$).

Beginning with 1989, 256 light curves in

bands B,V for 31 satellites were obtained. We have scores and even hundreds of light curves some objects together with the previously obtained ones in the integral light. Analyzing these materials, the employees of the LCS have carried out the studies of the rotating of some objects around their mass centers; they have defined the orientation of axes of rotation; some other tasks have been solved too. Known and newly worked methods have been applied (Bratiychuk et al., 1980, 1987, 1986, 1983; Epishev et al., 1983).

Periodic changes of brightness have been discovered at the majority of the obtained light curves. The visible periods changes brightness of the objects have been computed. The period of brightness changes for 790 passings of 46 different satellites have been defined in this way.

For some satellites, that have been observed for a long time, the tendency changes periods of brightness is evident. The data about the objects with the increase of period within the time is evident are given in Table 1. The periods of changes brightness are given for the start and the end interval of the observations.

It should be noted that the length of the light curve of the satellite according to which we define the value of the period T is up to 10 - 15 minutes, and often the very period is significantly less than this interval of time. In such cases some periods have been computed according to one light curves; these periods provided the average value and its error. It is obvious that the larger the relation of the length of one light curve to the average value of T , the more precise is the definition of the very period.

The results of Table 1 witness the braking of rotation of the objects that have ended their active existence. It is well seen with the objects 73108, 74029, 74032; the time periods of them have changed radically. These objects are cylinder-shaped, and in the reflected light diffusive component prevails. The character of the changes the periods of its brightness testify to the fact that the rockets - carriers within the time of their orbit - existence take a position that leads to minimal loss of kinetic energy. The latter occurs when during one period of

the satellite rotation round the Earth there occurs one rotation of the satellite round its own mass center.

The accuracy of computing of the visible periods changes of brightness is also defined by the characters of the satellite surface reflection. When there are flat mirror elements construction the accuracy of computing of the visible periods changes of brightness is much higher than in the case of the sun light diffusion dispersion. The maximum accuracy, thousandth parts of second, is achieved for objects 84065.03 and 86061.01.

Oscillation of the values periods relative to the average value at the large interval of observation have been noted for some satellites. This is illustrated in Table 2 for object 84065.03.

The light curves are used for solving various tasks. They can be transformed to the organizations that have interest in them.

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Table 1. The increase of the brightness change periods with time

N	N of the objects	Interval of observations		Starting and final values of the pe- riod in the given time interval	Average error the defining the brightness change periods
		start	end	T(sec)	σ_T (sec)
1	63053	1974.03.20-1980.06.13		10.40 - 16.10	0.20
2	68092	1978.04.24-1978.08.02		1.00 - 2.50	0.10
3	70047	1978.03.07-1982.05.28		7.00 - 55.00	0.21
4	71059	1979.08.08-1980.05.20		30.00 - 49.00	1.00
5	72066	1976.03.23-1976.09.14		35.00 - 39.00	0.60
6	73108	1976.03.23-1982.06.08		31.00 - 135.00	0.80
7	74029	1976.04.29-1982.06.02		25.60 - 117.00	0.64
8	74032	1976.03.23-1983.08.27		25.00 - 86.00	0.57
9	79003.02	1986.02.26-1986.05.07		32.78 - 41.00	0.25
10	85097.02	1986.09.04-1987.05.04		13.50 - 63.00	0.26
11	86061.01	1986.11.28-1992.03.19		1.493 - 1.625	0.002

Table 2. Results of defining the brightness change periods for the object 84065.03
(the time of signal storage $\Delta t = 0.1$ sec).

N	: D a t e	Interval of observation	T(sec)	σ_T (sec)
1	1986.05.05	20 50 40.3 - 20 51 48.5	1.206	0.003
2	1986.05.06	21 30 21.6 - 21 32 37.8	1.207	0.001
3	1986.05.07	20 32 12.5 - 20 34 41.2	1.207	0.001
4	1986.05.08	21 13 13.3 - 21 15 25.2	1.208	0.001
5	1986.05.13	21 20 12.5 - 21 22 30.0	1.194	0.001
6	1986.05.21	20 11 58.8 - 20 13 28.3	1.200	0.002
7	1986.09.02	18 19 57.8 - 18 21 44.6	1.202	0.001
8	1986.09.12	18 31 36.4 - 18 33 17.2	1.192	0.001
9	1986.09.16	19 35 48.7 - 19 37 11.4	1.196	0.002
10	1986.09.19	18 18 50.5 - 18 22 59.1	1.199	0.001
11	1986.09.25	19 06 41.8 - 19 08 49.7	1.205	0.001
12	1986.10.01	18 14 10.1 - 18 17 23.6	1.191	0.001
13	1987.01.03	16 08 53.3 - 16 09 50.6	1.195	0.002
14	1987.02.24	03 14 55.6 - 03 19 02.3	1.210	0.001
15	1987.02.25	02 19 02.1 - 02 20 09.6	1.202	0.002
16	1987.02.27	02 38 55.9 - 02 42 00.4	1.191	0.001
17	1987.03.02	02 24 34.5 - 02 26 02.6	1.193	0.002
18	1987.06.12	00 42 03.1 - 00 43 41.4	1.196	0.001
The average value of the periods			1.200	0.001

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PROGRAMS OF AES EPHEMERIDES CALCULATION

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ABSTRACT. A program of AES ephemerides calculation is developed which permits, from the given set of elemental orbit, to calculate ephemerides for several months' period.

Key words: orbital date, ephemeris service

In order to provide for normal positional observations the software is needed for recalculating AES position in orbit for any preset time moments from the known elements of AES orbit.

In DC OGU, the programs have been made up of AES ephemerides calculation which can work in the following regimes:

a) calculation of ephemerides for passive optical observations. In this regime, ephemerides are calculated only for the sunlit satellites and those visible in the dark part of the day (astronomical twilight and astronomical night) and being over some preset height above the observer's horizon. The program also permits to make calculations for other observational conditions as well. Ephemerides can be calculated with any set time step;

b) Calculation of ephemerides for laser optical observations. In this case ephemerides are calculated for all the night transits of a satellite above the observer's horizon as well as in the Earth's shadow;

c) Calculation of ephemerides for radio-location observations. In this regime, the conditions of the satellite being sunlit and the observer being in the night part of the Earth are entirely discarded, that is ephemerides are calculated for all the AES transits above the observer's horizon. The program permits to

make calculations for other observing conditions, too. Ephemerides can be calculated with any preset time step. Taking account of the motion of an ascending node and the orbit perihelion enables to calculate ephemerides for several months' period (when strong solar - atmospheric perturbations are absent) from the given set of elements of the orbit.

It should be also noted that programs elaborated by us were given trial throughout the seasons of observations in 1995-1996 for their testing and finding flaws which needed checking, correction, refinement. With their help, within the above seasons ephemerides were many a times calculated for observations of satellites "Okean-7" and "Sich-1". Calculations showed the ephemerides to remain precise enough for these satellites for three months, so, during observations on September 11th, 1996, satellite "Sich-1" was nearly 30 seconds slow as compared with ephemeris time. In early observational season of 1997 (February), from the data obtained from NTS RKI (rectangular equatorial coordinates of an ascending node), elements were determined of the orbit of middle component "bundle" - a group of satellites consisting of three objects. Ephemerides calculated from these elements under good weather conditions made it possible to carry out optical observations of these satellites up to the very end of their optical visibility period (February 19), and then after the advent of a new period of their visibility. The observations made once again confirmed a good quality of calculated ephemerides, and consequently the algorithms and programs elaborated at DC AO OSU being correct.

THE ANALYSIS OF A SMALL-AMPLITUDE STRUCTURE FOR COSMIC OBJECTS LIGHT CURVES

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ABSTRACT In the given work a small-amplitude structure for stabilized cosmic objects (CO) light curves is considered by an example of orbital complex "Salyut-7" light curves in various versions of the "bundle". Coefficients s and κ are determined of noise and "determined" components the velocity of ratio variation of which $\frac{s}{\kappa}$ may serve as a sign of undocking (docking) of the objects at their optical unresolvability.

Key words: Artificial satellites

Results.

Active artificial CO are, as a rule, stabilized. So are called CO, observational time of which ΔT is small relative to the period of their rotation round their own mass centre P i.e. $\Delta T < P$. Light curve data are characteristic of: greater degree of smoothness due to small values of a numerical derivative which implies a pronounced light curve behaviour level above the background, minimum value of a composite factor, explicit or latent periodic component. However, after primary reduction of analyzed light curves according to the due procedure (Beletsky, 1985), a structure was found inherent to all the orbital complex light curves and showing small light variations with amplitude up to 0.6 units of standard brightness close to the integral light variation within all the observation time. As light curves of stabilized CO are the least informative pertaining the light curve correlation with the form of respective objects, such light variations can be of interest for finding the character of their changes when observing CO during the undocking.

A small-amplitude structure for stabilized CO light curves is likely to be due to the angle change between the object symmetry axis and the orbiting object towards the observer, the former having details slightly different from reflective properties or due to marked condition variation in optical radiation scatter by the object. In some cases, certain symmetry present in outer CO design, that is in the arrangement of the above details as well, may provide an appreciable periodic component in the corresponding light curve. To ground the correspondence of small-amplitude light variations with real properties of objects observed, it is necessary to show that these variations be sufficiently determined not only by random processes occurring while the object passes the scattered optical radiation through the atmosphere. The given processes imply real CO noise component as quite necessary in all the light curves; it can be defined by the expression

$$S = \frac{1}{N} \sum_{k=1}^N \frac{\sigma(I_k)}{I_k} \quad (1)$$

where for each point of the light curve $(I_k) = (I_1, I_2, \dots, I_n)$ the empiric function magnitude obtained from observed stars, determines an interval of assumed I_k values. To find a small-amplitude component value of I let us make up auxilliary series

$$I_1^{min}, I_1^{max}, I_2^{min}, I_2^{max}, \dots, I_r^{min}, I_r^{max}, \dots, I_n^{min}, I_n^{max}$$

and

$$I_1^{max} - I_1^{min}, I_1^{max} - I_2^{min}, \dots, I_r^{max} - I_r^{min},$$

$$I_r^{max} - I_{r+1}^{min}, \dots, I_{n-1}^{max} - I_{n-1}^{min}, I_{n-1}^{max} - I_n^{min}$$

Then, the unknown is

$$\kappa = \frac{1}{2(n-1)} \sum_{r=1}^{n-1} (I_k) \frac{1}{\sum_{k=m_r}^{m_{r+1}} (m_{r+1} - m_r + 1)(2I_r^{max} - I_r^{min} - I_{r+1}^{min})} \quad (2)$$

Here $k = m_1, \dots, m_r, \dots, m_n$ are coordinates of series terms, locally minimum values of I_k . And the relation

$$\frac{S}{\kappa} = \frac{2(n-1)}{N} \sum_{k=1}^N \frac{\sigma(I_k)}{I_k} \left(\sum_{r=1}^{n-1} (m_{r+1} - m_r + 1) (2I_r^{max} - I_r^{min} - I_{r+1}^{min}) \left(\sum_{k=m_r}^{m_{r+1}} I_k \right)^{-1} \right)^{-1} \quad (3)$$

will determine an index of correspondence of some found light variations with real determined processes.

If we give a wanted initial value to index k , take $N' < N$ and substitute them to the expression obtained for $\frac{s}{\kappa}$, then an arbitrary part of the studied light curve consisting of N' values can be evaluated in terms of the given index. It is evident that determinancy degree of light curve structure is the more, the less is $\frac{s}{\kappa}$ index, and its total determination by random processes occurs at $\frac{s}{\kappa} \rightarrow 1$. For light curves of stabilized objects, the $\frac{s}{\kappa}$ index is likely to change in passing from some parts of the curve to the other. So, it is reasonable to study such a light curve by dividing the whole curve (I_k) into parts, the definite constant step being not too small $\Delta k > n \cdot \max(m_{r+1} - m_r)$, (n is the number of variations per curve part in Δk , $n_{min} > 1$) $(I_k)_1, (I_k)_2, \dots, (I_k)_i, \dots, (I_k)_{\frac{k}{\Delta k}}$ and by obtaining discrete function $(\frac{s}{\kappa})$ showing reliability of small-amplitude light variation determinancy within all the observation time of CO.

As is seen from the index $\frac{s}{\kappa}$ calculated for all the light curves of the orbital complex (the list is given below), not all the curves obtained during the object transit show small-amplitude variations due to random processes. Over half of all the curves have small-amplitude structure with a noise component being less than 60 i.e. $\frac{s}{\kappa}$ index varies from 0.40 to 0.64. It should be noted that 3 days transits up to

"Progress-24" separation from 11.07.1985 have $\frac{s}{\kappa} \approx 1$, i.e. without any determined component present. But on 11.07.1985 two observed light curves of undocked objects showed a determined small-amplitude component present with $\frac{s}{\kappa} = 0.510$ for "Progress-24" and $\frac{s}{\kappa} = 0.644$ for the complex "Salyut-7" - "Soyus-T-B". It is probable that such a great $\frac{s}{\kappa}$ change should be manifested while observing the docking and undocking objects per transit. Certain rate variation function of $(\frac{s}{\kappa})_i$ for some part of the corresponding light curve could be a sign of undocking or docking in this case even at optical unresolvability of the objects. Other parameters of small-amplitude structure of the light curve may change as well in this case.

A list of light curves of the orbital complex (CO 82-33-1)

1. 8.07.85, 20 02.290, "Salyut-7"- "Soyus T-13"- "Progress-24";
2. 8.07.85, 21 38.425, "Salyut-7"- "Soyus T-13"- "Progress-24";
3. 8.07.85, 23 15.221, "Salyut-7"- "Soyus T-13"- "Progress-24";
4. 11.07.85, 19 51.197, "Salyut-7"- "Soyus T-13"- "Progress-24";
5. 11.07.85, 21 27.227, "Salyut-7"- "Soyus T-13"- "Progress-24";
6. 13.07.85, 19 11.961, "Salyut-7"- "Soyus T-13"- "Progress-24";
7. 13.07.85, 20 47.562, "Salyut-7"- "Soyus T-13"- "Progress-24";
8. 15.07.85, 20 08.182, "Salyut-7"- "Soyus T-13" and separately "Progress-24" (undocking of "Progress-24");
9. 17.07.85, 19 28.003, "Salyut-7"- "Soyus T-13";
10. 18.09.85, 17 16.096, "x";
11. 18.09.85, 17 22.066, "Salyut-7"- "Soyus T-13"- "Soyus T-14";

It is probable for the objects passing their own mass centres with large periods during their detachment to have marked rotational motion round the axes, particularly for those whose activity is not suggested, as direction coincidence of detaching force vector-pulse with the common objects symmetry axis is unlikely. The resulting momentum depends on de-

taching force vector-pulse, the angle between its direction and a common symmetry axis of objects and mass distribution about the volume of the detached object. It depends on the ratio of momentum formed at the undocking and of constant resulting forces of different nature acting on the orbiting object whether the object will have a constant angular velocity of rotation round the axis passing through its mass centre or whether it will oscillate about some steady equilibrium position with rather a small period not to be found in analyzing the light curve per transit. Such oscillations may be only with slight amplitudes and will be shown in small-amplitude structure of light curves only at small values of S provided the atmosphere is most favourable during observations, radiation recording of sufficient frequency, and the least level of dark current noise. To check up the supposition on the object oscillation after undocking, an analysis was made on the periodicity by the method (Beletsky, 1985). The structure was found inherent to all the light curves of two parts of the spaceship "Progress-24" light curves. For the curve $\frac{s}{\kappa} = 0.510$, and for the curve part with maximum amplitude $\frac{s}{\kappa} = 0.339$, i.e. the determined component value is about 50%.

Similarly, an analysis of orbital complex light curves was made for which $\frac{s}{\kappa} < 0.5$. In small-

amplitude structure of light curves obtained before and after undocking, no periodic component has been found.

For the most efficient revealing of a reliable determined small-amplitude component, it stands to reason to carry out complementary CO observations by the above method by determining a multidimensional vector field preset in the celestial sphere at the observation moment. It implies that each point of the celestial sphere should fit a multidimensional vector with components

$$S_{\nu} = \frac{1}{N_{\nu}} \sum_{k=1}^N \frac{\sigma(I'_k)_{\nu}}{(I'_k)_{\nu}} \quad (3)$$

$(I'_k)_{\nu}$ is the set of extended in time photoregistrations of extraatmospheric radiation sources with different light values. The given problem can be solved by using the theory of electromagnetic radiation distribution in the turbulent atmosphere for the optical range to determine digital filter parameters for small-amplitude structure of light curves.

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A LASER-PHOTOMETRIC OBSERVATIONAL COMPLEX OF THE ODESSA ASTRONOMICAL OBSERVATORY

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ABSTRACT. The creation of a laser-photometric complex for AES observations, which enters into the net of laser-location AES observations on the territory of the Ukraine, nears completion at Kryzhanovka Station of the Odessa Astronomical Observatory. The station is equipped to meet high standards and permits successfully carrying out works within the frames of international projects.

Key words: Artificial satellites

At the astronomical station Kryzhanovka, the construction of a laser-photometric complex for AES observations nears completion. The complex incorporates:

- 1) an 80-cm Ritchey-Cretien reflecting telescope on the altazimuthal mounting from the fast cinetelescope SKT 1-70. as a light-detector apparatus a pulse-counting photometric photometer-polarimeter is manufactured and placed in Cassegrain focus, the prime focus being designated for the matrix TV camera. The program is changed by positioning the secondary Cassegrain mirror to the meniscus corrector for prime focus. The instrument is designed for photometric and position observations of AES.

- 2) Laser telescope TPL-1M with 1m-primary mirror in diameter designed for laser-long range observations of geodetic Lageos-type AES as well as geostationaries.

- 3) A modernized laser-long range set of LD-2-type for navigation AES observations.

- 4) Tracking system KT-50 with a count-pulsing photometer for recording AES light variations.

The complex incorporates a complement of time service apparatus.

The 80-cm telescope is erected in an observatory tower having a dome 6 m in diameter. There are special premises for apparatus and a work-room, these together with the observatory tower constitute the whole architectural ensemble.

Laser telescope TPL-1M is housed in the building 9x9 m in size with a common roof rolling away. It accomodates rooms for an operator, recording and control apparatus and a laser. To the building is attached a 6×9 m flank for making reduction of observations.

The laser set LD-2 and electrophotometer on the tracking system KT-50 are mounted in two housings of the whole pavillion of prefabricated metal constructions and in special premises for apparatus. The roof rolling away consists of two halves for each instrument separately.

In July 1995 the Ukrainian aero-geodetic enterprise of the Main management for geodetics, chart-making and cadastre at the Soviets of Ministers of the Ukraine related the site in Kryzhanovka to the International net of GPS (item N 17). Kryzhanovka station, Odessa Astronomical Observatory, enters into the laser-location AES observations net organized according to the project of Ministry of Education of the Ukraine. Putting into operation the given laser-photometric complex for AES observations will permit the Odessa Astronomical Observatory to participate in the works carried out within the frameworks of different international project and programs.

AN 80-cm UNIVERSAL AZIMUTHAL TELESCOPE FOR AES OBSERVATIONS

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ABSTRACT Based upon altazimuthal mounting SKT 1-70 an 80-cm telescope is being built for photometric and position observations of low- and high- orbital AES. The telescope has two foci: a prime focus for panorama light detectors, and a Cassegrain focus for a photometer.

Key words: Artificial satellites

Results

An 80-cm telescope for AES observations is being produced on the basis of fast cinetelescope SKT 1-70 having an altazimuthal mounting and designed for multicolour photometry, polarimetry and position observations of low orbital, high orbital and geostationary AES.

Due to the problem set it was necessary to provide maximum penetrating power at minimum focal lengths of the optical system to attain the largest nondistorted field of view. Above all, it was urgent for position observations made with the aid of panorama light detectors where alongside with AES the stellar images should be in the field of vision for coordinate references. Besides, specificity of a number of observations for example, according to the Global Star program, suggests obtaining images of several closely located AES in the same field of view.

Based upon the above requirements a proposal task was made up for manufacturing the telescope. The presence of two foci are designated: a prime one - for a panorama light detector, and a Cassegrain focus - for a multicolour photometer-polarimeter. In order to provide maximum penetrating power, the opti-

cal system should have a minimum possible diameter of the secondary mirror and minimum of correcting systems. Owing to this N.N.Fashchevsky developed an optical system incorporating one-element meniscus corrector for prime focus and Ritchey-Chretien system for Cassegrain focus which provides a maximum field without any supplementary correction optics.

Technical Performance of the Telescope is as follows:

- 1) The primary mirror diameter is 800 mm
- 2) The secondary mirror and meniscus diameter - 180 mm
- 3) The system: Ritchey-Chretien for a Cassegrain focus and meniscus corrector for prime focus
- 4) The prime focus - 2.88 mm, $A=1:3,6$;
- 5) Equivalent focal length of the Cassegrain - 10 m, $A=1:12,5$
- 6) Linear corrected field of view - 30 mm

The work at different foci is carried out with an interchangeable secondary mirror. The meniscus is erected permanently, adjusted and focused with a light detector apparatus for prime focus. When the work in Cassegrain focus is to be done, the secondary mirror is set up onto the meniscus cell.

The telescope tube represents a delicate construction of the surveyer type which is mounted on a swinging platform of the set-up SKT 1-70. The tube inclination in one direction only strictly at height permitted to develop a more simplified design of the tube and primary mirror support accessories.

The telescope optics was manufactured at optic workshops, Odessa observatory, by N.N.Fashchevsky and Yu.N.Bondarenko.

The telescope tube, dome opening and dome rotation designs were developed by Yu.A.Medvedev and L.S.Paulin and manufactured at big astronomical workshops of Odessa observatory. The apparatus for registering data and telescope control is developed by R.A.Chaichuk and other researchers of OAO OSU cosmic investigation department participating in the work.

The telescope can be operated in a semiautomatic regime when guiding a moving AES with the help of two observers, one of them drives on azimuth, the other - on altitude. For this,

each work-place is supplied with a guide and a corresponding telescope monitoring system. An automatic regime of telescope operation is designated when the guiding is carried out from the AES image in a light detector with the aid of a control computer.

The telescope is being set up at astronomical station Kryzhanovka, Odessa astronomical Observatory, in a 6m-dome tower. This constitutes a whole architectural ensemble with premises for registering and control apparatus and for observational data reduction.

POSITIONAL AND PHOTOELECTRIC OBSERVATIONS OF CA SIMILAR TO THE OBJECTS SUGGESTED FOR LAUNCHING ACCORDING TO THE "GLOBAL STAR" PROGRAM

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ABSTRACT The given work deals with results of observations of AES being analogues of CA "Global Star" carried out to study capabilities of interdisposition of satellites suggested for launching according to the "Global Star" in the zone of their closest approach.

Key words: Artificial satellites

Introduction

The fixation of interdisposition of CA "Global Star" in the zone of their closest approach is a new problem for the Astronomical observatory OSU, when analysis is to be done of capabilities of available facilities, proposals for their refinement should be developed as well as possibilities estimated of putting into operation these new optical tracking instruments which have been purchased and ready for mounting in the nearly accomplished constructions (by 80 and more per cent).

The work has been carried out in the following directions:

- choice of analogues of CA "Global Star";
- calculation of elemental orbits and ephemerides for CA data;
- making test positional and photometric observations with optical observing facilities available in Odessa, Lvov and Uzhgorod;
- carrying out test photographic and phototelevision observations with optical observing facilities available in Odessa, Lvov and Uzhgorod;
- development of an algorithm for "windows" determination of launching PH (carrier-rockets) according to the "Global Star" pro-

gram.

- modernization of available instruments and producing new optical observing facilities to realize the "Global Star" program;
- development of technical proposals according to the "Global Star" program in the hardware part.

Description of objects.

Motion dynamics

According to the preliminary project of work representing a preliminary research stage on the "Global Star" program, at the Space Research Department of Astronomical Observatory, Odessa University (OKI AO OGU) in February 1997 observations were made of cosmic objects analogues suggested for launching in 1998-1999.

Objects-analogues were chosen by Kharkov Military University (KhMU), Elemental orbits of these objects were submitted by them as well.

From the elemental orbits presented, according to our program, ephemerides were calculated for the above objects for Odessa, Lvov and Uzhgorod for all the visibility period (up to 19 th February).

These objects were observed in February 1997. The objects were discovered on 7, 9, 11, 15 and 17 February 1997 in the points corresponding to ephemerides calculated in DCI AO OSU.

The above objects were observed as a compact moving group ("Bundles") consisting of

three objects with constant light marked by us through "const.", of 6th - 9th stellar magnitude depending upon observational conditions. One of these three objects, at the discovery moment, at the onset transit, moving ahead of all the rest and designated as the "first" (1st) is commonly brighter than the other two by 0.5 - 1.0, that is magnitude 6-6.5.

Throughout the transit the objects were considerably moving relative to each other and by the end of observations the objects had even changed their places along route 2 and 3 on 17.02.1997. Object 1 was commonly much ahead of the others so that the whole figure looked like an acute triangle extended towards the bundle motion.

A minimum angular distance between objects during observations constituted nearly 11 arc/min whereas maximum approximated 2 degrees, that corresponds to the distance between them in a picture plane of 6 and 66 km respectively for heights of 60 degrees.

The given angular travels indicate, evidently, not only variations in objects visibility aspect but also real displacements of these objects relative to each other in space.

Method of observations and the obtained material description

At DCI AO OSU, observations of analogous groups of objects ("bundles") were carried out in observing seasons 1992-1993. Those were 83-056-7; 84-012-1,2,3,4,5; 86-014-1,3,4; 90-050-1,2,3,4; 91-076-1,2,3,4,5 mainly active functioning American reconnaissance spacecrafts, and as a result, rich experience has been gained in making such observations. According

to the specificity of the given objects, the procedure of their observations is developed involving the successive placing into major optical axis (MOA) a tracking system (carrying in the photometer diaphragm) of each object.

In the process of observational reduction, a coordinate information is given in the form of graphs representing piece functions. By using parallel obtained photometric information it is possible to filter false coordinate points registered by coordinate-time system KT-50 when changing over the instrument from one object to the other. At this time the photometer is recording the sky background.

In addition to observations carried out on KT-50, the given objects were observed from ephemerides calculated in DCI AO OSU in the settlement Mayaky by a television group. Photos of objects were obtained from the screen of a videocontrol equipment.

In the conclusion, it should be noted that test observations of CA data testify to the possibility of detection and control of behaviour of orbital cosmic objects suggested for launching according to the "Global Star" program if the analogues submitted to us by KhMU correspond to the suggested ones. Unfortunately, the data on shape, sizes and coating of objects were not presented by Kharkov Military University, therefore we could not carry out the mathematical modelling of CA data and judge the adequate correspondence.

At present DCI AO OSU is busy with carrying out modernization of observational complex KOD-1 to obtain alongside with coordinate and photometric information that of phototelevision, too during KA transit in the visibility zone of the observing station.

PROGRAM OF AES ORBIT DETERMINATION FROM MEASUREMENT DATA OF ASTRONOMICAL STATION ("ORBITA - M")

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ABSTRACT. A program is developed of determining AES orbits from measurement data of one or several astronomical stations. Its algorithm is rather stable to small errors of measurements and permits to use data with low accuracy for calculations. The use of several transits data enables to increase precision of orbital semi-major axis determination by nearly 10000 times.

Key words: orbital date, ephemeris service

The "Orbita - M" program has been developed in DC AO OSU and designated for AES orbits determination from the data of positional measurements of one or several observing stations. The given program version is a total result of research work carried out within the framework of the theme "Ballistics - 1" jointly with GKB "Yuzhnoye" (Dnepropetrovsk) in 1996 - 1997. It permits to use data both of one and several AES transits in the visibility zone of one or several observing stations. In the given program version the number of stations is restricted to three, with that, up to 40 positional points can be used in case of one transit or up to 10 positional points per transit within four transits. In the given program version, observational data in topocentric azimuthal system of coordinates are used as initial data. The algorithm applied in this program enables to use data for calculations the precision of which is much less than that of data used in classic algorithms for solving similar problems. We succeeded in attaining this with inclusion into the program algorithm a problem of finding minimum functional representing a weighted average sum of standard

deviations of calculated satellite positions from the measured ones in the fixation points. To minimize the functional a method of conjugate directions is applied. After estimating steps from all the minimization parameters a conclusion can be drawn that by using data of other transits the precision of orbital semi-major axis determination increases nearly by 10.000 times. The work-program and its capabilities are shown by the control example. As initial data, ephemerides values have been taken of sputnik "Sich-1" coordinates calculated for the period of 55-10 October 1996 for Odessa, Lvov and Uzhgorod from data of NTTS KhMU of 30.09.96 as well as ephemerides coordinate values for the group of sputniks ("Bundles") calculated for the same points according to the NTTS KhMU data of 20.01.97. The station coordinates are kept in a separate file, its contents can be replenished, if necessary, by the user.

The algorithm of calculations was many times checked up with a model, then by the program itself, when calculating AES orbits carried out within the framework of "Ballistics-1" theme, during the preliminary investigational stage according to the program "Global Star" in 1997, and was highly estimated both on the part of observers and of the customer.

Below are given elemental orbits of satellites calculated in the control example. As is seen from the below results, in spite of the fact that coordinates for calculations have been taken with one decimal sign only, that is not very precise, the obtained elements of the orbit of the above satellites are rather accurate. So, the scatter in semi-major axis determination

for the "Sich-1" satellite from different coordinate sets and versions of calculations for Lvov-Odessa-Uzhgorod, Odessa-Odessa turned out to be not more than 60 m whereas for the group of satellites ("Bundles") not more than 8 m. The inclination scatter for the above satellites proved to be not more than 0.1 degree. Eccentricity deviations because of its smallness turned out to be relatively great - about 0.0025. It should be noted that the deviations of elemental values from the control ones do not exceed the above scatter magnitudes. It testifies to the good reliability of the calculation algorithm used. If more precise coordinates are used in calculations, the precision of elemental AES orbits determination will be essentially higher.

Elements of elliptic AES orbits

"Sich-1" from the data of stations Lvov 06.10.96 and Odessa, 08.10.96.

Date (date - month) and moment of ascending node crossing:

06 - 10 03:51:12.120 UT

$a = 7034.293$ $e = 0.00417$ $\Omega = 98.457$

$i = 82.519$ $w = 73.116$ $dp = -0.0000018$

Drac. period = 97.78566 min.

"Sich-1" from the data of station Odessa, 2 transits, 05.10 and 08.10.96.

Date (date - month) and moment of ascending node crossing:

05 - 10 03:24:26.216 UT

$a = 7034.302$ $e = 0.00389$ $\Omega = 99.323$

$i = 82.446$ $w = 53.257$ $dp = -0.0000014$

Drac. period = 97.78575 min.

"Bundle" from the data of stations Lvov 14.02, Odessa 15.02 and Uzhgorod 16.02.97.

Date (date - month) and moment of ascending node crossing:

14 - 02 16:48:38.745 UT

$a = 7492.267$ $e = 0.00310$ $\Omega = 282.281$

$i = 63.330$ $w = 120.987$ $dp = -0.0000000001$

Drac. period = 107.43989 min.

"Bundle" from the data of stations Odessa 11.02, Lvov 12.02 and Uzhgorod 13.02.97.

Date (date - month) and moment of ascending node crossing: 11 - 02 17:10:58.512 UT

$a = 7492.260$ $e = 0.00308$ $\Omega = 289.813$

$i = 63.366$ $w = 138.671$ $dp = 0.0000000000$

Drac. period = 107.43989 min.

Наукове видання

Вісті Одеської астрономічної обсерваторії
том 10 (1997)

Англійською мовою

Технічний редактор М.І.Клишнін

Підписано до друку 02.06.99. Формат 60х84/8.

Ум. друк. арк. 17,205. Друк офсетний. Папір офсетний. Тираж 300 прим. Зам. 456.

Видавництво «АстроПринт»

370026, м. Одеса, вул. Преображенська, 24.

Тел.: 138 (0482) 26-96-82, 26-98-82.