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

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

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

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

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

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

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

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

Table 1.

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

Remark: * - Woodwoorth & Hughes (1976)

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

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

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

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

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

$$r_2 = 10.984\ 10^{15}\left[\frac{n_0\, r_0^2}{10^{36} sm}\right]^{2/3} \qquad (3)$$

$$\left[\frac{\nu}{10GHz}\right]^{-0.7}\left[\frac{T_e}{10^4 K}\right]^{-0.45}$$

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

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

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

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

Key words: Stars: Cataclysmic: Polars

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