PHYSICAL CHARACTERISTICS OF THE NEBULAR ENVELOPE AROUND THE SYSTEM RY Sct

V.V. Golovatyj and M.Yu. Skulskij
Politechnic Institute, 290013 Lvov, USSR

ABSTRACT

The absolute distribution of the energy from infrared up to far ultraviolet spectral region were analyzed in the spectrum of RY Sct. The temperature and the radius of the central star have been derived as well as the physical and geometrical characteristics of a disk-shaped gas envelope surrounding it. The abundances of helium and oxygen in the envelope have been analyzed.

The circumstellar gas structures in the massive close binary system RY Sct can be considered as an analoque of those observed in β Lyrae (*Skulskij* 1985) . Notwithstanding , there is an evidence that the envelope in RY Sct is a bit unique expressing a high degree of mass loss from the system. It is evident that only a deep analysis of the observations in the wide spectral region could bring good undestanding of the physical conditions in this nebular envelope. In this paper we have made an attempt to do it.

The absolute radiative fluxes as derived from the equivalent widths of the emission lines [NII] , [OIII] , [FeIII], and those similar listed in the paper by *Skulskij et al.*(1991) are given in Table 1 . Assuming $A_v = 4^{m}.12$ they all were corrected for the interstellar extinction according to the papers by *Nandy et al.* (1976) and *Strajzhys* (1964) and correspond to the phase of the maximum of light of the star. Using the method described in the papers by *Bojarchuk et al.* (1988) and *Strajzhys* (1977), the continuum of the spectrum was derived from the wide band photometry given by *Zakirov* (1985) and *Ciatti et al.* (1980) and from the ultraviolet spectra obtained by *West* (1990).

The emission lines in the spectrum of the envelope of RY Sct resemble the spectrum of a nebulosity excited by the radiation of a star inside . The fact can be proved by analyzing the Balmer decrement that correspons rather to recombinations than to collisions of atoms. The computations performed here have given the following ratios for the line intensities in RY Sct : $H_\beta : H_\gamma : H_\delta : H_\varepsilon = 1 : 0.48 : 0.28 : 0.15$ and $\lambda\lambda 3820 : \lambda\lambda 4026 : \lambda\lambda 4471 : \lambda\lambda 5876 = 0.25 : 0.50 : 1 : 2.44$. For comparison , we present here the same ratios but produced by the recombination processes ; in this case they are $1 : 0.47 : 0.26 : 0.16$ and $0.26 : 0.47 : 1 : 2.76$ respectively.

Electron density N_e and temperature T_e , the chemical abundances in the gas, the temperature T_* of the exciting star (one can suppose the black body radiation), and the geometry of the system can be generally considered as the main parameters characterizing the physical conditions in the envelope . The only information about N_e and T_e can be found in the intensity ratio of the auroral and nebular forbidden lines [NII] $\lambda\lambda 5755 / \lambda\lambda 6548 + \lambda\lambda 6584$ but , in fact , it has to be considered as ambiguous because another similar couple of lines does not exist . In our case , the ratio of the line intensities gives $N_e = 5.10^5$ cm^{-3} and 1.10^5 cm^{-3} for $T_e = 10000$ K and 20000 K respectively.

Table 1 .

element $\lambda(A)$	$W_\lambda(A)$	$E_\lambda.10^{-12}$ erg.c.$^{-1}$cm^{-2}	element $\lambda(A)$	$W_\lambda(A)$	$E_\lambda.10^{-12}$ erg.c.$^{-1}$cm^{-2}
H 3970	0.145	18.5	[OIII] 4959	0.10	6.0
4101	0.29	34	5007	0.51	29
4340	0.58	59	[NII] 5755*	1.03	29
4861	1.85	122	6548*	3.10	60
HeI 3819	0.075	10.4	6584*	5.56	109
4026	0.18	21	[SIII] 6716*	0.22	4.2
4471	0.45	42	[SIII] 6313*	0.48	10
5875*	3.90	102	[FeIII] 4658	0.85	70
[OII] 3727	0.04	5.8	4701	0.46	39

Notice: The data for the lines marked by asterix were obtained with the 6 m telescope. They were transformed to the ESO observational system.

The temperature T_* of the star responsible for the radiation of the envelope was derived using the Zanstra method modified by *Glushak et al.* (1984). All the line intensities of HeI were corrected for the collisional radiation using the method of *Peimbert* and *Torres-Peimbert* (1987), nevertheless for the final analysis could be exploited only the measurements of HeI λλ4471 . It remains to add that RY Sct was supposed to be at the distance of 2 kpc and that all the computations were performed for Te = 10000 K and 20000 K and corresponding to them N_e= 5.10^5 cm^{-3} and 1.10^5 cm^{-3} respectively. From these two sets of data the values expressing T_*= 50000 K and 35000 K could be derived. Henceforward, the data corresponding to the second set of the temperatures (T_e= 20000 K, T_*= 35000 K) will be given in brackets.

If the envelope is supposed to be spherically symmetrical , then the radius of the star can easily be find out . In our case, the radius obtained in this way, r_*= 5.8x10^{10}cm (1.2x10^{11}cm), is by more than one order smaller than that derived from spectral and photometrical observations (*Skulskij* 1985 and 1991 , Antokhina and Czerepaschczuk, 1988).

But in our opinion, the envelope is rather a disk than a spheroidal formation in which the radiation is not totaly absorbed by the gas envelope . In such a case, coefficient K_{scr} characterizing the degree of screening the star by the envelope could well describe the true line intensities in the system . The coefficient, expressed as a ratio of the surfaces of a sphere and a disk-shaped stratum was derived by the comparison of the fluxes obtained in Table 1 with those in the ultraviolet continuum; the latest were taken from the extraterrestrial observations made by *West* (1990) . The results are: K_{scr}= 21 , r_*= 1.1x10^{12}cm, h = 1.5x10^{14}cm (K_{scr}= 14, r_*= 1.6x10^{12}cm, h = 2x10^{13}cm) where h is the thickness of the disk-shaped envelope. The remaining geometrical parameters were derived in the following way: Using the method described in the paper by *Golovatyj* and *Yacyk* (1979) , the coefficient of the energy dilution W = 1.5x10^{-13} (3.4x10^{-12}) and the inner radius r_o= 3.3x10^{15}cm (2.7x10^{14}cm) were first computed . Then the volume of the envelope $V = 4\Pi R^2 E(H_\beta)/\varepsilon(H_\beta)$ = 1.5x10^{48}cm^3 (8.6x10^{49}cm^3) and following from it the outer radius r = 5.5x10^{16} (1.2x10^{18}) cm were finally derived . The radiative flux $E(H_\beta)$ in the line H_β at the distance from the earth to RY Sct is given in Table 1 , the radiative coefficient ε computed for the unit of the volume of the nebular gas was taken from *Pottash* (1987).

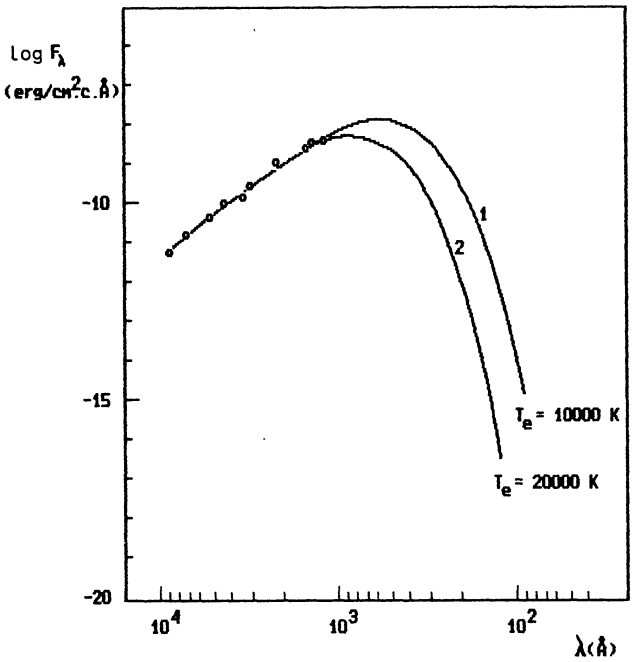

Fig. 1.

In Fig. 1 , there is a comparison of the theoretical and the observed energy distributions in the spectrum of RY Sct in the wide spectral region from the infrared up to the far ultraviolet . The curve 1 corresponds to the first model (T_e= 10000 K) and the curve 2 to the model with T_e= 20000 K . As you can see, the ambiguity of the solution for the electron temperature is quite evident.

As for the chemical composition of RY Sct, one one could only derive the abundances He/H and O/H. The abundances He/H were estimated as 0.70 (0.36), those of O/H as 4.1×10^{-5} (4.7×10^{-6}) . Even though there are some differences in both models adopted , one can state that He/H exceeds only a bit the "normal" abundances of He but O/H is by one order below them.

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