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DUST CLOUD IN THE CI CYGNI SYSTEM

CI Cyg is a well known eclipsing symbiotic star with $P = 855^d$ (for references see Kenyon et al. 1982). This paper reports differences in the behaviour of the emission lines HeII λ1640 (Balmer α) and HeII λ4686 (Paschen α) during the 1980 eclipse. The variation of the line ratio of these lines led us to the conclusion that a cloud of dust particles, responsible for the far UV extinction, must be situated in the system.

An interpretation of the spectrophotometric observations of CI Cyg during the 1980 eclipse (Mikołajewska and Mikołajewski, 1983) suggests the presence of a partially eclipsed ionized gas cloud with $T_e \approx 3\cdot10^4$K and $n_e > 10^6$ and a fully eclipsed source radiating like a blackbody with a temperature of about 4000K. The eclipsing body is the M4III-II star filling its critical Roche lobe. The evaluated large inclination of the orbit ($i > 86^o$) denotes that the observed blackbody radiation originates in the edge of a disc with a radius of about 75 $R_\odot$. The results cited above support qualitatively the model of CI Cyg given by Bath and Pringle (1982).

I U E observations have shown eclipses in the intercombination lines, in HeII 1640 and in the hydrogen Balmer continuum λ3000Å. In the optical region eclipses are visible in the hydrogen Balmer lines, HeI 4471 and in HeII 4686. Eclipses in the UV (λ < 2000 Å) are approximately twice as long as those observed in the optical lines and in the Balmer continuum. This phenomenon is illustrated in Figure 1a for HeII 1640 and HeII 4686. Moreover, the eclipse in HeII 4686 is about twice as deep as in HeII 1640. It is easily seen that the I and IV contacts in λ4686 are very close to the II and III contacts in λ1640. The flux ratio of these lines varies with phase (Figure 1b), and is close to the theoretical value ("case B" recombination value of $R = f_\lambda 1640/f_\lambda 4686 \simeq 6.85$) at the mid-eclipse only the nebular component is visible. At other phases HeII 1640 seems to be apparently fainter than predicted. As both these lines should be created in the same region, we cannot explain this phenomenon in terms of optical depths, in the optically thick case the amplitude should be greater for HeII 1640.

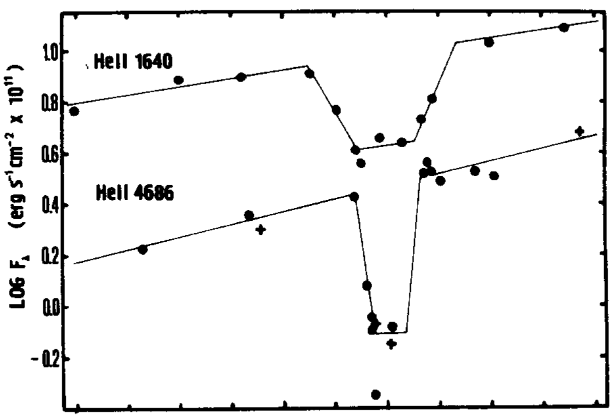

Figure 1a

The eclipses in HeII 1640 (Stencel et al. 1982) and HeII 4686. Fluxes are dereddened with E_{B-V} = 0.45 (Mikołajewska, Mikołajewski 1980). Crosses indicate observations of Oliversen and Anderson (1982).

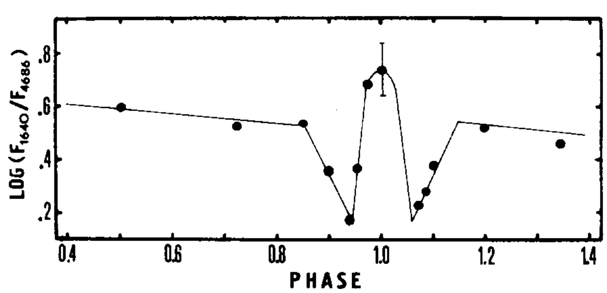

Figure 1b

Variations of the 1640/4686 ratio with phase. The additional eclipsing factor may be a dust cloud (see text and Figure 2).

Infrared observations show a strong excess in the N band 10 μm of CI Cyg (Taranova, Yudin 1979, 1981), this is usually attributed to dust grains. These grains may be responsible for the observed behaviour of the 1640/4686 ratio if they are small enough to be optically active only in the far UV range (λ < 2000 Å). The dust cloud should have such a location in the system as to provide the explanation of the longer "eclipses" in the far UV and the absence of extinction at the mid-eclipse. Most of the late-type luminous stars show the circumstellar 10 μm emission feature traditionally attributed to silicate dust particles (Woolf 1973. Gillet et al., 1968). This feature is also observed in some symbiotic stars: HM Sge (Puetter et al., 1978), CH Cyg (Bopp, 1981), V1016 Cyg (Aitken et al., 1980), R Aqr (Stein et al., 1969). It is interesting to mention that also in early type stars 10 μm silicate emissions are observed together with high circumstellar extinction in the $\lambda < 1800$ Å range (Sitko et al., 1981).

Our proposed model of CI Cyg assumes in addition to the components of the previous model the presence of small dust particles in the central parts of the nebula, near the disc, and between the two components. Low gravity and low temperature around the Lagrangian L_1 point may offer the best conditions for the grain formation, providing the strong anisotropy of grain ejection. On the other hand the estimated temperature of the disc boundary layer should be about 10^5K, so that in the vicinity of the disc, grains should evaporate. In this situation we may expect that the grain growth will be impossible and only small dust particles may exist. Probably condensation and evaporation processes coexist in a kind of equilibrium. The presence of a cloud of small dust particles in CI Cyg (Figure 2) explains qualitatively the observed phenomena.

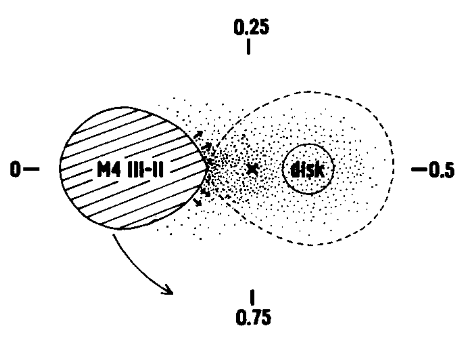

Figure 2

The schematic model of CI Cyg. The shaded region represents the anticipated dust cloud. Arrows indicate the region of dust formation. The stream of matter from L_1 to disc is not indicated. The earlier UV eclipses are caused by the increasing optical depth of the dust on the line of sight. The anomaly of the 1640/4686 ratio disappears when the cloud is eclipsed by the cool component. The mass ratio q = 0.74 (Lijima, 1982).

It is also possible that dust grains are formed in the stream of matter escaping through the Lagrangian L_1 point. In the presence of sufficiently steep pressure gradient the temperature and pressure of the gas may be lowered in a short time. The estimated time in which the matter from L_1 point reaches the disc boundary is ~100 days - apparently long enough to allow dust grains to reach radii of the order of 10^{-7} cm or more. A similar phenomenon e.g. in dwarf novae is not possible as in this case the gas is transferred from L_1 point to the disc in the time of few hours.

The proposed model implies some variability in the N band of CI Cyg: close to the phase "zero" it should reach the minimum. IR spectra between 5 and 25 μm (e.g. using the IRAS satellite), may give us data of great importance.

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