THE DECAY TIME AFTER A THERMONUCLEAR FLASH

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ABSTRACT. The drag luminosity produced by a secondary embedded in a nova envelope is calculated and it is assumed to liberate gravitational energy. The results of a preliminary calculation show that the time for envelope ejection and therefore for the light decay varies sharply with the binary distance. It would be considerably reduced if the binary distance is $a < 2\ R_{O}$. It is suggested that this is the main difference between the thermonuclear runaway of symbiotic stars and nova systems, instead of other physical parameters.

Kenyon & Truran (1983) pointed out at the importance of a known difference between symbiotic systems and nova systems: the dimensions of the binary systems. The orbital periods of symbiotic stars are of years, those of novae of hours. The different order of magnitude of the energetics of novae can be understood considering that the binary separation in novae (10^{11} cm vs. 10^{13} cm of symbiotics) implies interaction of the secondary with the expanding envelope, since the time of the optical miximum. McDonald (1980) and McDonald et al. (1985) estimated that this additional energy contributes to blow off the nova envelope in a much shorter time than it would be otherwise, switching off the nuclear reactions and causing the rapid decay of many novae.

We considered the structure of a slow nova shell (v = 300 km/sec) obtained in a full scale hydrodynamical calculation of Prialnik (1985), with luminosity at maximum $L = 3.41\ 10^4\ L_{\odot}$ and effective temperature $T = 7128$ K. We assumed mass outflow at a constant rate $\dot{m}_o$ and variations of the density profile with a law that matches the subsequent evolution of the model. The white dwarf, of 1.25 $M_{\odot}$, had accreted $10^{-7}\ M_{\odot}$ at a rate $10^{-11}\ M_{\odot}$/yr before the outburst. Envelope ejection was completed in about 345 days.

Supposing that a secondary of 0.5 $M_{\odot}$ orbits in the ejected shell, the drag luminosity is:

$$L_D = \pi R_2 \rho V^3_{orb} \tag{1}$$

where we assumed for the density ρ the average value in the layers of

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nova shell around the secondary, that rotates with a period almost equal to the orbital one (a few hours). If all the drag energy contributes to liberate gravitational energy, additional mass flows from the radius R = a (where a is the binary separation) at a rate:

$$\dot{m}_D = \frac{L_D a}{GM} \tag{2}$$

The total mass outflow from a fixed radius (the photospheric boundary at maximum) is in this case:

$$\dot{m} = \dot{m}_o + \dot{m}_D \tag{3}$$

The density profile also varies more sharply beyond the secondary. When all the mass beyond the radius r = a has been lost, it is just:

$$\dot{m} = \dot{m}_o \tag{4}$$

If not all the drag energy liberates gravitational energy, it also contributes to increase the temperature, effecting the radiation pressure. It was not calculated yet how the mass outflow would vary in this case. We also neglected accretion of material by the secondary, whose accretion radius is of the same order of the stellar radius (the Roche lobe radius). It was verified that accretion with the Bondi Law would mean that most of the envelope (95%) is accreted by the secondary and not ejected from the system: this is very unrealistic. It is not clear if and how much material is accreted and only a full scale hydrodynamical calculation could give an answer. We solved the angular momentum equation at each time step and checked that the binary distance varied of an irrelevant factor(10^{-6}%). Shara et al. have shown that accretion of a small fraction of the envelope would cause an increase of the separation, but we checked that this uncertainty does not significantly change the result that we show in Fig. 1.

The mass outflow rate due to the drag luminosity is, on the contrary, comparable to $\dot{m}_o$ and very significant. If the time required for ejection of the envelope is the typical decay time of the light curve, that for return at the pre-outburst magnitude, the drag luminosity can transform a slow nova in a very fast nova, if the secondary is at distance $a < 2\ R_o$. We show the variation of the decay time with the binary distance in Fig. 1. In a successive calculation we intend to check the effect of the drag energy on a symbiotic-type shell produced by a weak thermonuclear flash like in the model of Prialnik & Regev (1987). The significant difference between the slow flash of a symbiotic and the sudden burst of a nova could not only (or not at all?) be due to the higher luminosity of the white dwarf and to the mass transfer rate higher than $10^{-8}\ M_\odot$/yr (see Paczynski & Rudak, 1983, Iben, 1977, Prialnik & Regev, 1987), but mainly to the greater binary distance of symbiotic star.

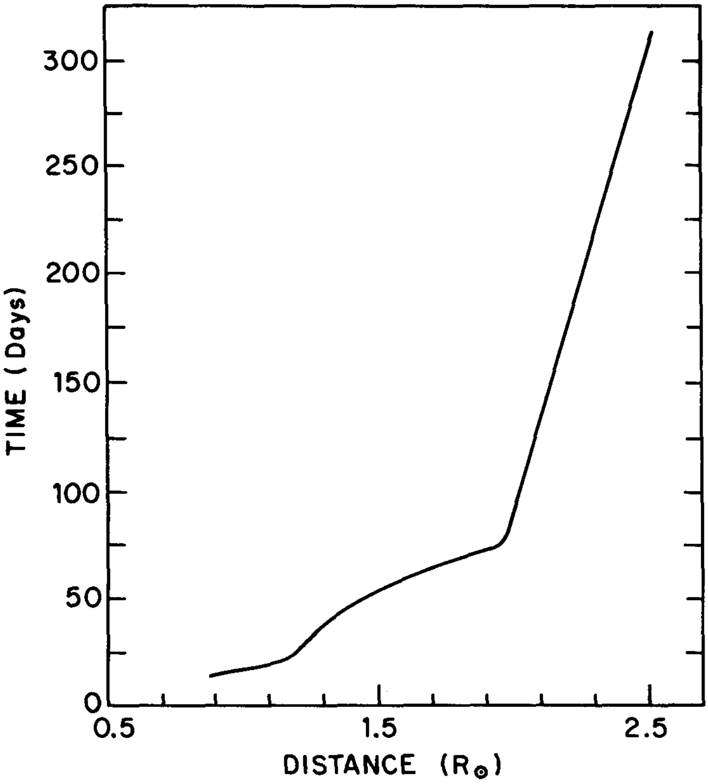

Figure 1. Variation of the time for envelope ejection with the binary distance.

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