AN "ACCRETOR-PROPELLER" MODEL OF CH CYGNI

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The most spectacular episode in the history of CH Cyg was undoubtedly a sudden drop of brightness (by about 1 mag) during the last weak of July 1984, coinciding with the ejection of two collimated jets (Taylor *et al.* 1985) perpendicular to the line of sight (Solf 1987) and the orbital plane (Luud *et al.* 1986). Supercritical accretion cannot be responsible for the jet ejection mechanism, because the luminosity of the accreting component was always about 2 orders of magnitude lower than the Eddington limit (Mikolajewska *et al.* 1987). This mechanism is also inconsistent with the rapid drop of brightness coinciding with the ejection of material. Simultaneously, it is conspicuous that the increase of brightness to optical maximum was also rapid (~1 mag from July to September 1981; e.g. Kaler *et al.* 1983).

We propose a preliminary model of the activity of CH Cyg based on the theory of an oblique rotator (Lipunov 1987) and assuming an accreting white dwarf with magnetic axis nearly parallel to the rotational axis as the energy source of the hot component. The luminosity of a rotator due to dissipation of rotational energy and release accretion energy is redistributed by the outer layers of material accreted from the M6 giant wind and observed as the 9000K pseudophotosphere ($R \simeq 10-2R_{\odot}$). We also assume that both the rapid increase of brightness in 1981, as well as its sudden drop in 1984, was due to a transition through *"the catastrophic equilibrium"*, in which a small variation in the accretion rate made the rotator pass from the *"propeller state"* into the *"accretor state"* (1981) and vice versa (1984). The luminosity of the rotator abruptly changes as a result of these transitions.

The luminosity of the *accretor* just before the drop in brightness and the *propeller* just after the drop in luminosity (Lipunov 1987) is:

$$L_{before}=\dot{M}_C GM/R_0+\mu^2\omega/3R_C{}^3 \; ; \quad L_{after}=\dot{M}_C GM/R_A+\mu^2\omega/3R_A{}^3$$

where $\dot{M}_C$ is the "catastrophic" accretion rate and M, R_O, μ, $\omega=2\pi/P$ are the mass, radius, magnetic dipole moment, and angular rotational velocity of the white dwarf, respectively. The Alfven radius (R_A) is equal to the corotation radius (R_C) at the time of the transition ($R_A(\dot{M}_C)=R_C$), so:

$$R_A=(\mu^2/\dot{M}_C(2GM)^{1/2})^{2/7} \; ; \qquad R_C=(GM/\omega^2)^{1/3}$$

J. Mikolajewska et al. (eds.), The Symbiotic Phenomenon, 233–234.

The solution of this system of 4 equations yields:

$$R_c/R_0=(2/9)^{1/2}[(L_{before}/L_{after})-1]\ ; \qquad \omega=(GM)^{1/2}R_c^{-3/2}$$

$$\dot{M}_c=(L_{before}-L_{after})(1/R_o-1/R_A)/GM\ ; \qquad \mu^2=\dot{M}_c(2GM)^{1/2}R_A^{7/2}$$

The spectroscopic orbit (Mikolajewski *et al.*, *this Proceedings*) and the mass ratio $q \simeq 3.5$ (Mikolajewski *et al.* 1987) implies $M=1M_\odot$. The photometric and IUE data suggest $L_{before}=240L_\odot$ and $L_{after}=70L_\odot$ (see also Mikolajewska *et al.* 1987). Taking $R_o=10^9$cm we have: $R_c \simeq 5R_o$, $\mu \simeq 10^{33}$Gcm^3, $\dot{M}_c \simeq 10^{-7}M_\odot$/yr and $P \simeq 200$s. The derived value of the magnetic field is close to that expected for magnetic white dwarfs (King 1985). The rotational period of the white dwarf would be difficult to detect in the case of CH Cyg because of the optically thick envelope.

In the proposed model, the jets represent material from accretion columns blown off along the rotation axis at the time of the transition from *accretor* to *propeller* ($A \rightarrow P$). It is very striking that the theoretical collimation angle for a jet, $\theta=(R_o/R_A)^{1/2}=0.45$ (Lipunov 1987), is comparable to that observed in CH Cyg (20°–30°; Taylor *et al.* 1985). Adopting the mass in the jets, $2\times10^{-6}M_\odot$ (Taylor *et al.* 1985), the work performed by the magnetic field during the transition $A \rightarrow P$, $W=GM_{jets}M(1/R_o-1/R_A) \simeq 10^{44}$ergs, is comparable to the kinetic energy of the jet motion. In CH Cyg, about 1% of the cool giant wind can be captured by the white dwarf (see Mikolajewski *et al.* 1987). To mantain the "catastrophic" accretion, $\dot{M}_{wind} \simeq 10^{-5}M_\odot$/yr is required, which is unacceptable for the M6 giant. This suggests that material must be accumulated around the white dwarf for a long time before accretion is possible. Using formulae given by Livio & Warner (1984) and the known orbital parameters of CH Cyg an accretion disk with a radius $0.5-2.5\eta^2 R_\odot > R_c \simeq 5R_o$ can be formed, (η is dimensionless parameter of order 1). We estimate that about $10^{-6}M_\odot$ was accreted during the active period 1963–1987 and that a comparable amount of material was ejected during the 1984 event. Therefore, at least 100–1000 years are necessary to reconstruct the disk-envelope around the white dwarf for an assumed, reasonable mass-loss rate from the giant, $\dot{M}_{wind} \simeq 5\times10^{-7}-5\times10^{-8}M_\odot$/yr. In fact, no activity of the hot component was detected before 1963 (*e.g.* Dziewulski *et al.*, *this Proceedings.*).

Finally, the accreted mass required to initiate a hydrogen shell flash on a white dwarf is about $5\times10^{-6}M_\odot$ (*e.g.* Prialnik 1987); thus we may expect a nova like eruption in each new activity cycle. In fact, R Aqr, the symbiotic system most closely related to CH Cyg, also seems to be an ancient nova (Kafatos & Michalitsianos 1982)

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