EXTREMELY SLOW NOVA PU VULPECULAE - SEVEN FAT YEARS AFTER MAXIMUM

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ABSTRACT. UBV photometry and spectroscopy of the symbiotic nova PU Vul support the suggestion that the system consists of a mass-losing M-giant massive component and a C-O dwarf accreting hydrogen-rich matter, mimicing in outer appearance an F-supergiant.

1. INTRODUCTION

The cataclysmic variable PU Vul, originally designated as object Kuwano-Honda 1979, was studied intensively since the first outburst by several groups of observers around the world. Its photometric and spectroscopic history till 1985 was summarized by several authors (cf. Kenyon, 1986). The object maintained B~15-16 prior to its slow rise to B~9 in 1978-79. After the first maximum in 1979, it started gradual fading followed by a rapid decline since February 1980. PU Vul then remained at minimum for about 200 days and then recovered to V 8.5 in another 200 days (see Figure 1).

The pre-outburst spectrum was classified as gM4-M5. Spectra acquired during the maxima were typical for novae in outburst, and their classification amounted to A5 II - F8 Ia. The occurence of nebular emission lines during deep minimum in 1980 supported the general impression that we have witnessed the outburst of a very slow nova, such as RT Ser or RR Tel. The binary nature of PU Vul was firstly suggested by Belyakina et al. (1982) and this view gained impressive support by future investigations. The deep minimum in 1980 is then explained by the formation and subsequent dilution of the dust envelope around the bursting component (Belyakina et al., 1984).

Paper presented at the IAU Colloquium No. 93 on 'Cataclysmic Variables. Recent Multi-Frequency Observations and Theoretical Developments', held at Dr. Remeis-Sternwarte Bamberg, F.R.G., 16–19 June, 1986.

Astrophysics and Space Science **131** (1987) 487–491.

2. RECENT PHOTOMETRY AND SPECTROSCOPY

UBV photometry was compiled from papers by Kolotilov (1983, 1984) and Chochol et al. (1984) - see Figure 1.

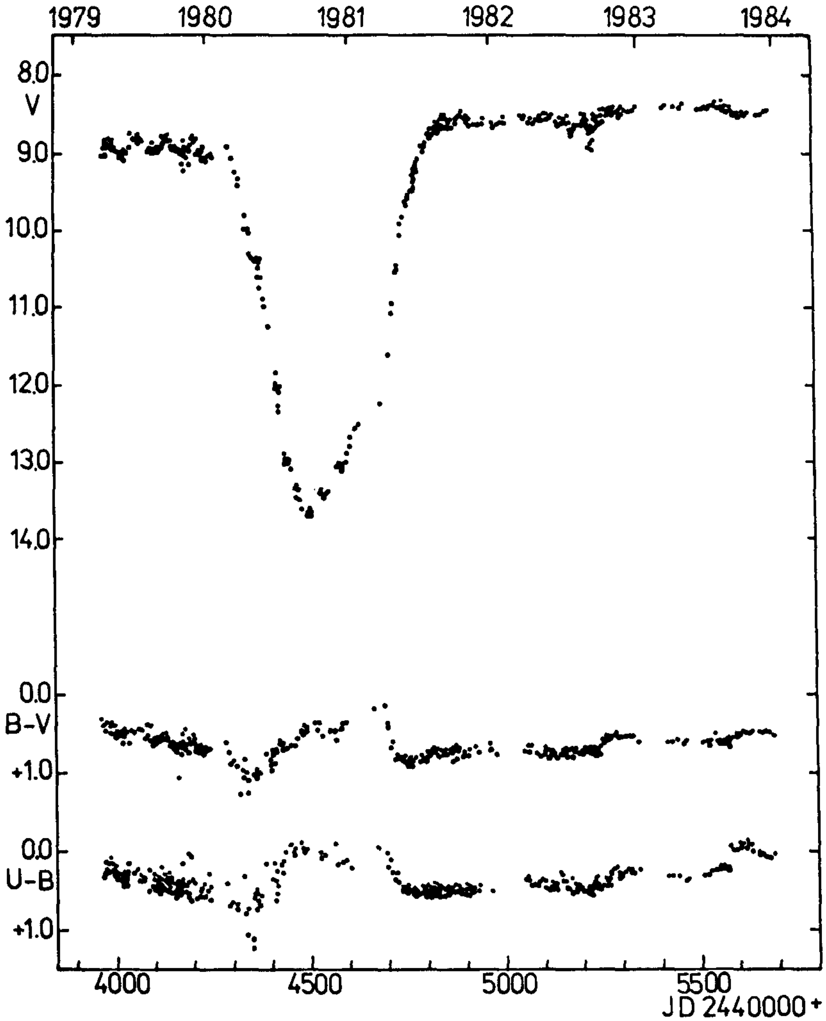

Figure 1. UBV light curves of PU Vul.

https://doi.org/10.1017/S0252921100105263 Published online by Cambridge University Press

The deep minimum in V and relevant changes in the colour indices were quantitatively explained by Efimov (1986) who considered in detail the formation of dust particles in the envelope of the supergiant component. Low-amplitude oscillations with the period of 78.1 days (see Chochol et al., 1981) were explained by Fadeyev (1984) as non-linear pulsations of the yellow supergiant. By using the periodmean density relation he derived a radius of the supergiant component R = 154 $R_\odot$, assuming its mass equal to 1 $M_\odot$.

Furthermore, three small dips are evident in the UBV data at JD 2 445 150, ...180 and ...230. These are followed by two subsequent decreases (blueings) of the colour indices (B-V) and (U-B) at JD 2 445 300 and ...600.

Radial velocities of the absorption as well as emission lines belonging to the yellow supergiant were compiled by Chochol and Grygar (1986). Additional data by Yamashita et al. (1986), Kolotilov (1985) and Chochol et al. (1986) were also included in Figure 2.

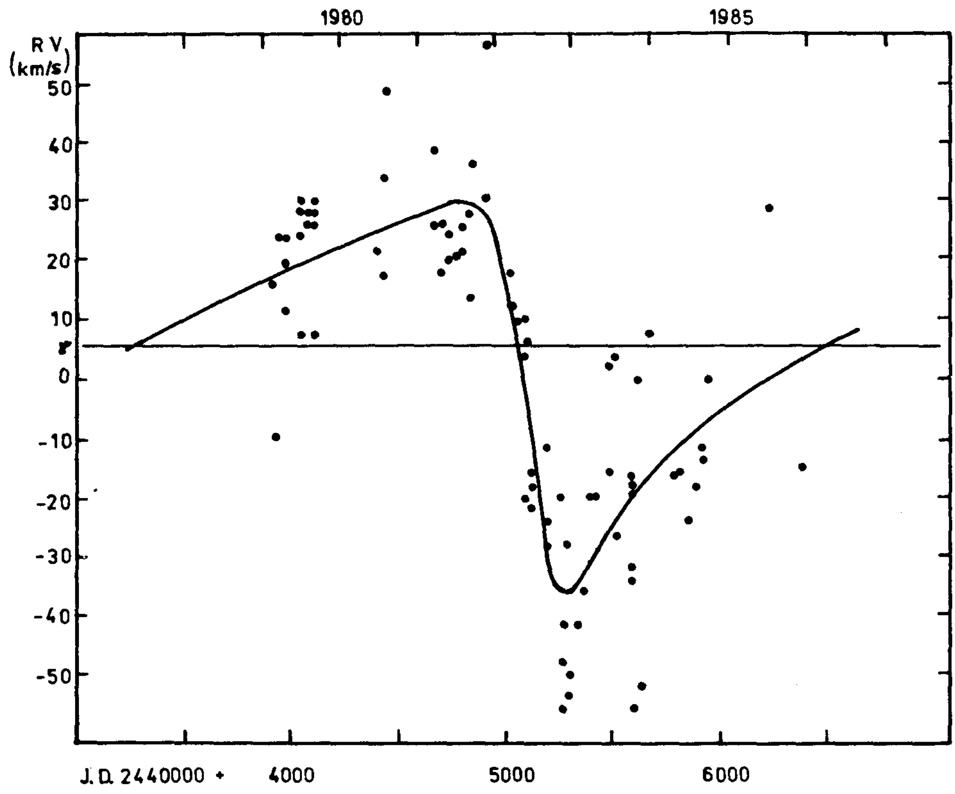

Figure 2. Radial velocities of PU Vul and the computed spectroscopic orbit.

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These data were used for the derivation of the preliminary spectroscopic orbit using the code SPEL (Horn, 1986):

P = (3200 ± 530) days
e = 0.64 ± 0.06
K_1 = 34 ± 2 km/s
ω = 115 ± 5 °
γ = 6.1 ± 1.2 km/s
T (pri.min.) = 2 445 130 JD
T (periastr.) = 2 445 168 JD
$f(M) = 5.9\ M_{\odot}$
$a_1 \sin i = 1650\ R_{\odot}$.

3. DISCUSSION

Although the diagram of radial velocities displays considerable scatter (apparently due to mass transfer from M6 giant to the F supergiant followed by an expansion of the atmosphere of the F supergiant), the preliminary orbit gives some interesting clues to the photometric variations. Times of primary minimum and periastron passage correspond well to photometric dips mentioned above. No radial velocity changes were observed in the course of the deep photometric minimum in 1980, thus excluding the possibility of its explanation by an eclipse of the F supergiant by the M giant. It is also interesting to note that photometric blueing occured in the time of most negative radial velocities.

Fadeyev (1984) and Gershberg et al. (1986) pointed out that the absolute visual magnitude of PU Vul of $-\ 6.^m3$ fits well in the HR-diagram computed by Iben (1982) for a white dwarf of mass 1.01 $M_{\odot}$ accreting hydrogen-rich matter at a rate $10^{-9} M_{\odot}$/yr.

Thus cumulation of evidence favours the explanation of PU Vul as a symbiotic nova that underwent a thermonuclear runaway event in the atmosphere of a C-O dwarf. The mass-losing component must be a massive red giant (> 7.5 $M_{\odot}$), resembling the massive M-giant in the system V 1329 Cygni (Chochol and Vittone, 1986).

A more definite model of the system would require the extension of the present sets of data for another decade.

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