NOVA V1500 CYG - PHOTOMETRY AND PERIOD VARIATIONS STUDY

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This study aims to present our photometric observations of Nova Cygni V1500 1975, and to discuss the period changes of brightness variation on the basis of all available data.

The Nova was observed from 2 September 1975 to 26 October 1976 using the single channel UBV photometer attached to the 60-cm reflector of the Ostrowik station of Warsaw University Observatory. The brightness of the Nova decreased considerably during that time and it was necessary to use a sequence of four comparison stars. The variable was usually monitored in the V filter and occasionally measured with B and U filters. The V band is not well suited for observing novae in the nebular stage, since the dominant light contribution comes from O III emission lines. The same set of filters was kept, however, for the sake of uniformity, since the observations had started at short notice with the equipment used at that time. In addition, the observations made after June 1976 which are crucial for the period determination, were obtained at large air mass and with interfering twilight, so that only the V filter could be used. The large air mass and the strong emission lines at the edge of the V spectral band required the introduction of a second order extinction coefficient for the V observations from December 1975 on; the errors introduced this way do not exceed $0\overset{m}{.}01$. The details of these observations will be published elsewhere (Semeniuk et al. 1977).

The short-term variability of Nova V1500 Cyg was discovered by Tempesti (1975 a, b) and Koch and Ambruster (1975 a, b). From published times of light extrema and those obtained from two long series of observations made in Ostrowik on September 8 and 18, a period of $0\overset{d}{.}1410$ was derived (Semeniuk 1975). This period was later confirmed by Campbell (1976), Chia et al. (1976), Rosino and Tempesti (1976) and Young et al. (1977).

We have observed 45 times of minima and maxima; additional light extrema were determined from already published observations. For references see Semeniuk et al. 1977. The earliest values showed a considerable scatter and/or a certain tendency to an increased

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frequency of variations. It was not clear whether the phenomenon was quasiperiodic or periodic with a slowly increasing frequency, but Semeniuk et al. (1976) found a large period decrease, fully confirmed by the extended set of data. Since observations were not made in 1976 until the end of Spring 1977, these have not been confirmed for a whole cycle. Two sets of elements were used to calculate the O - C residua for the times of light extrema observed in 1975 and 1976, respectively:

$$\text{JD Hel. Min.} = 2442664.305 + 0.1410\ E_{75} \qquad (1)$$

$$\text{Max.} \qquad .364$$

$$\text{JD Hel. Min.} = 2442919.515 + 0.1384\ E_{76} \qquad (2)$$

$$\text{Max.} \qquad .588$$

The residua are plotted in Figs. 1 and 2, and represent extended versions of already published curves (Semeniuk et al. 1976).

During the first two weeks of observations, the period was $0^{d}.1410$ and it started changing at the end of September. Since the very small amplitude of the light variations caused a considerable scatter in the O - C diagram, the size of this period change is difficult to determine. In October, the period was only $0^{d}.1399$, while in November and December 1975 it appeared quite constant at $0^{d}.1394$.

The amplitude of the light variations changed systematically and also from night to night. A typical value for middle September was $0^{m}.15$ with only slight colour dependence. At the end of September, it decreased to about $0^{m}.03$ and continued to be small, with only occasional increases during the next few months.

Figure 2 shows that the period changes occurred at least until August 1976, i.e., almost a full year after the nova explosion. During Summer 1976 the period changed from $0^{d}.1385$ to $0^{d}.1380$. The last and probably final value was observed by Tempesti (1977 a, b) in December 1976 and Summer 1977. In 1976 the amplitude of the light variations increased gradually and was strongly wavelength dependent due to the influence of strong nonvariable nebular emission lines. The highest amplitude observed was $0^{m}.7$ in the blue light on October 26, 1976.

There were some doubts whether the correct period is twice as long as ours because of observed distinct differences between odd and even extrema (Koch and Ambruster 1975 a, b, Prokof´eva and Abramenko 1977, Young et al. 1977). Fig. 3 might help to identify

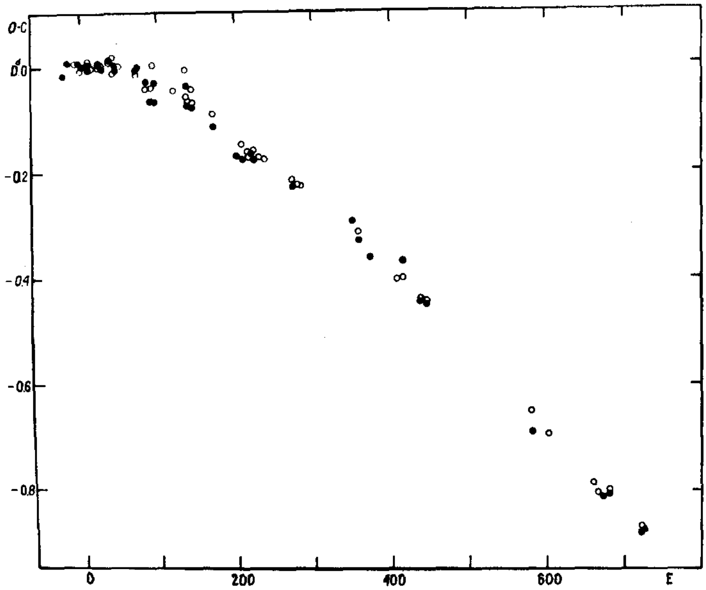

Fig. 1. O - C diagram for times of extrema observed in 1975. Filled dots correspond to minima, open circles to maxima.

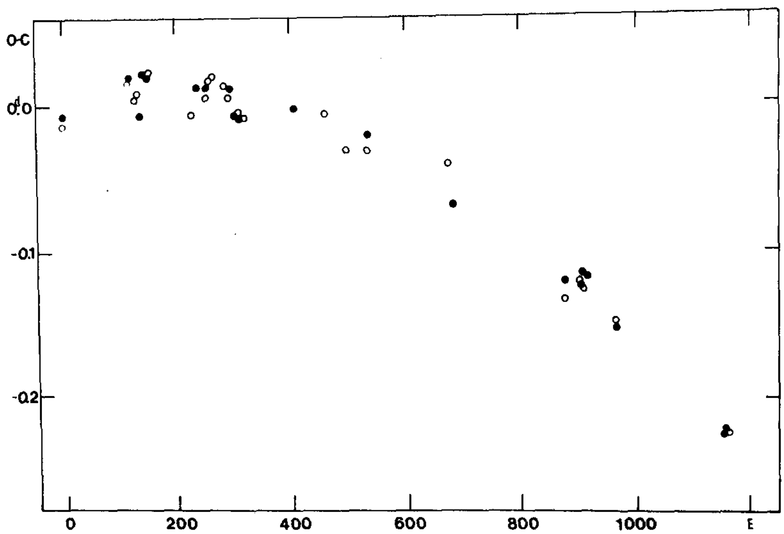

Fig. 2 Same as Fig. 1 for year 1976.

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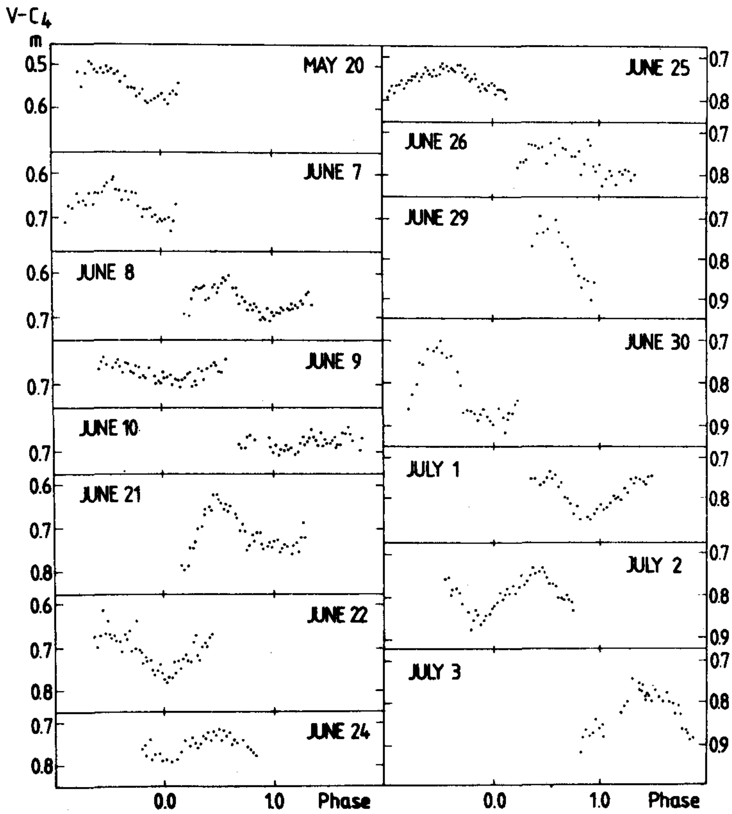

Fig.3. Observations made over the interval from May 20 to July 3, 1976 plotted versus phase. The phase 0 corresponds to the even minima and phase 1 corresponds to the odd minima.

a possible difference in the shape and depth of the odd and even light extrema. In this figure, all our yellow observations made between May 20 and July 3, 1976 are plotted versus phase. The phase was calculated using the elements (2). Phase 0 corresponds to even minima, phase 1 to odd minima. The shape of the light curve and the amplitude of the short period variations clearly show night to night or even cycle to cycle changes but there are no regularities that occur at every odd and/or every even cycle.

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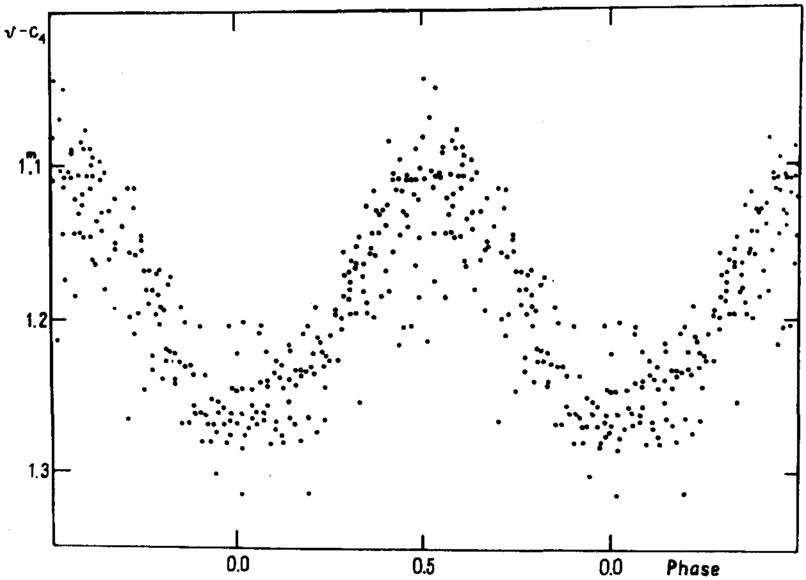

Fig.4. Composite yellow light curve of Nova V1500 Cyg based on observations from September 22 to September 30, 1976.

Figure 4 shows a composite short period yellow light curve of the nova obtained from observations between September 22 and September 30, 1976. The phase was computed with the elements JD Hel. Min. = 2443040.358 + 0.1380 E_{76}.

Figure 5 shows the blue observations obtained at the night of October 26, 1976.

Generally speaking, the light variations of Nova V1500 Cyg were periodic with the period systematically decreasing by over 2% in the course of one year. The amplitude was varying both irregularly from night to night, as well as systematically, reaching $0^{m}.7$ in the blue filter at October 26, 1976. At this time its wavelength-dependence was strongest due to the presence of strong constant nebular emission.

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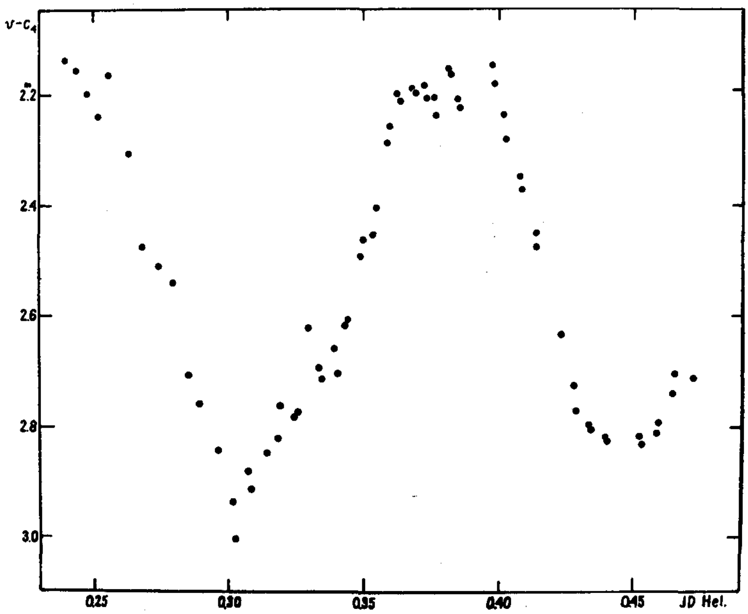

Fig. 5 The blue observations obtained at the night of October 26, 1976.

It is believed that all novae are close binaries and that their explosions are accompanied by the exchange of matter between the components. Only once, namely in the case of DQ Her, was the period change determined after the explosion (Ahnert 1960). The period increase of DQ Her by 0.2% is consistent with the assumption that the 10^{-3} part of the mass of the star is expelled from it. The effect for Nova V1500 Cyg has however, the opposite direction, and is ten times larger. Not excluding the interpretation of a period change due to mass transfer, we stress the existence of another model, based on an apparent analogy with the dwarf nova VW Hyi (Semeniuk et al. 1976). The period of the short term variation is assumed to be identical with the rotational period of the magnetic star, similar to the case of AM Her. The extended magnetosphere synchronises the rotation and the orbital motion, as it does in the case of the last mentioned star.

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We can expect that the explosion increases temporarily the size of the rotating white dwarf with the resulting increase in period. Gradual settling of the star to the normal configuration would be reflected in a corresponding decrease of the rotational period by momentum conservation. The magnetic field is needed here for explaining the anisotropic radiation.

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D I S C U S S I O N of paper by SEMENIUK, KRUSZEWSKI, SCHWARZENBERG-CZERNY and CHLEBOWSKI:

FRIEDJUNG: How much mass transfer would be needed for the period changes according to your two hypothesis?

SEMENIUK: Such a period change has only been observed for one other nova - DQ Herculis. Its period change was explained by a mass loss of 10^{-3} $M_{\odot}$. In the present case, a mass ten times greater would be required.

KOPAL: The period change in V1500 Cyg (or any other nova) does not specify uniquely the amount of mass/lost or transferred); but rather the change in the amount of momentum.

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