ON THE POSSIBLE SHORT-PERIOD IRREGULAR LIGHT FLUCTUATIONS OF V1357 CYG =CYG X-1

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ABSTRACT

Photoelectric observations in U, B, V, were carried out to study the possible rapid (during a night) fluctuations of the close binary system V1357 Cyg, including the X-ray source Cyg X-1. Assuming the existence of irregular fast light fluctuations in the X-ray source Cyg X-1, the conclusion can be drawn that during these observations in 1979 the amplitude of the variations did not exceed 0.04 mag.

There is at present no general consensus about possible short-period (i.e., within a few hours) irregular light fluctuations of V1357 Cyg in the optical region. (Cherepashchuk et al., 1974) conclude that the light undergoes irregular variations from night to night only and that it does not exhibit any rapid fluctuations in excess of $0^m.008$ within time intervals from 15 min to 5 hours. On the other hand, Kardopolov et al.,(1978) imply that the question is still open because they observed light variations with an amplitude of $0^m.04$ near maxima in three cases. It is, however, not impossible that these fluctuations reflect at least partly observational errors.

A recent paper by Natali et al. (1978) discusses anomalous light curves of Cyg X-1 which were obtained in April-May 1975 during its high state. From an analysis of their optical observations, the authors conclude that with the increase of the radiation in the X-ray band, the system's optical component (i.e., HD 226868) shows large fluctuations, mainly in V, with an amplitude ranging from $0^m.06$ to $0^m.10$ within an interval of 20 to 40 minutes. These fluctuations disappear with the return of the X-ray radiation to the lower state. Thus, the observed fluctuations are likely to be related to the high state of the X-ray source.

Three colour photoelectric photometry of Cyg X-1 have been carried out at the Abastumani Astrophysical Observatory in order to investigate in detail its photometric properties. The observations were made from 1975 to 1979. An extensive paper dealing with the reduction of the data and a discussion of the results is in progress. We shall here

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only report on one aspect of our observations.

Within the framework of a collaborative program on massive close binary systems, we have undertaken to study possible, rapid irregular fluctuations of V1357 Cyg, i.e., fluctuations occurring during one night. Accordingly, photoelectric observations were performed with the AZT-14 48 cm telescope at Abastumani during some nights in 1979. The observations were carried out in our UBV system which is very close to the standard one. A pulse-counting photoelectric photometer was used and the stars "a" and "c" from Liutij (1972) served as comparison stars. For stars of this magnitude, our usual r.m.s. errors are of the order of $0^m.005$ to $0^m.007$ for one observation.

An examination of the observations permits us to draw some preliminary conclusions. In all cases, the differences between the two comparison stars ($m_a - m_c$) as well as between the variable V1357 Cyg and star "a" ($m_v - m_a$) show larger fluctuations than the differences between the variable and star "c" ($m_v - m_c$). This clearly indicates a possible variability of the comparison star "a". It should be noted that this star has been used by various investigators of Cyg X-1 but that little is known about its possible variability. Walker and Quintanilla (1978) mention a variability of star "a" with a period of tens or hundreds of days and also that it is double. Furthermore, it exhibits periodic micro-variability. According to their data, the amplitudes of the periodic variations are $0^m.0037$ and $0^m.0032$, corresponding to periods of 1.3608 and 0.8055 days, respectively.

Our observations indicate that the amplitude of star "a" may be more than quoted above. To illustrate this, we shall discuss briefly the observations for each night separately.

Figure 1 shows the differences $m_v - m_c$, $m_v - m_a$ and $m_a - m_c$ in the V-band during the night of June 24-25, 1979; the abscissa values here and in the following diagrams are given in U.T. The magnitude differences were corrected for extinction in the Earth's atmosphere and we shall only consider nights with stable transparency. is the phase of the orbital motion, computed from

$$\text{Min} = \text{JD } 2441166^d.22 + 5^d.60125\ E$$

The peak-to-peak scatter in ($m_a - m_c$) is about $0^m.03$ and is greater than that of ($m_v - m_c$). This is also clearly seen in the B-band during the same night (Figure 2). Moreover, the ($m_a - m_c$) and ($m_v - m_a$) differences vary in opposite sense, indicating an increase in the light of star "a". In B, the variation of ($m_a - m_c$) is about $0^m.05$ and that of ($m_v - m_c$) is about $0^m.04$.

A similar state of affairs was also observed on June 29-30, 1979. The observations in V are shown in Figure 3. The peak-to-peak amplitude ($m_a - m_c$) is of the order of $0^m.05$ and that of ($m_v - m_c$) is $0^m.04$. Thus, during this night, the Cyg X-1 variation differs somewhat from that of June 24-25, 1979.

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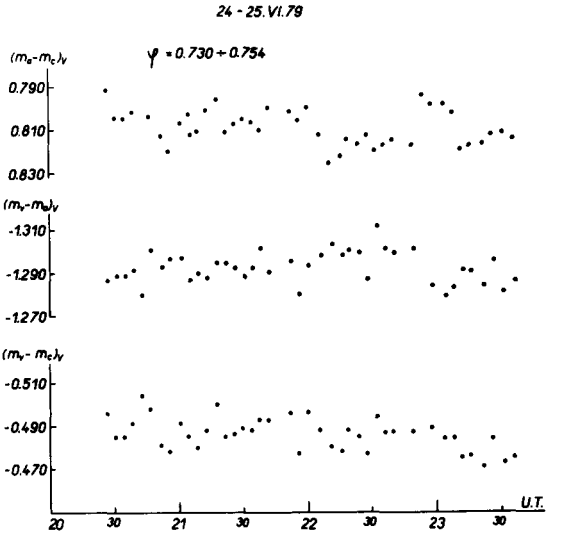

Fig. 1

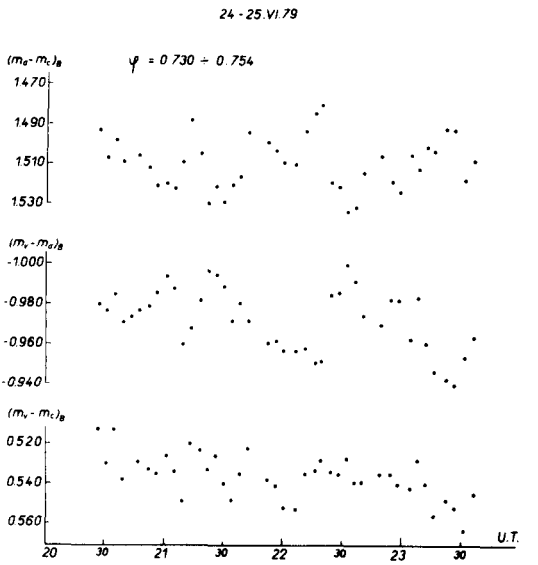

Fig. 2

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The duration of observations on July 19-20, 1979, is shorter (Figure 4 and 5). This night there were more marked fluctuations between the comparison stars ($m_a - m_c$) in V, amounting to $0^m.05$; the trends of the ($m_a - m_c$) and ($m_v - m_a$) differences are the same. In the B-band, the variation of all three differences is the same and does not exceed $0^m.035$.

The observations on August 2-3, 1979, were interrupted at midnight because of an instrumental failure, but again the fluctuations in ($m_a - m_c$) are greater and more pronounced in B (Figures 6 and 7). In V the fluctuations of ($m_v - m_c$) reach $0^m.04$ and of ($m_a - m_c$) about $0^m.045$, while in B the variations are $0^m.05$ for ($m_v - m_a$) and even $0^m.07$ for ($m_a - m_c$).

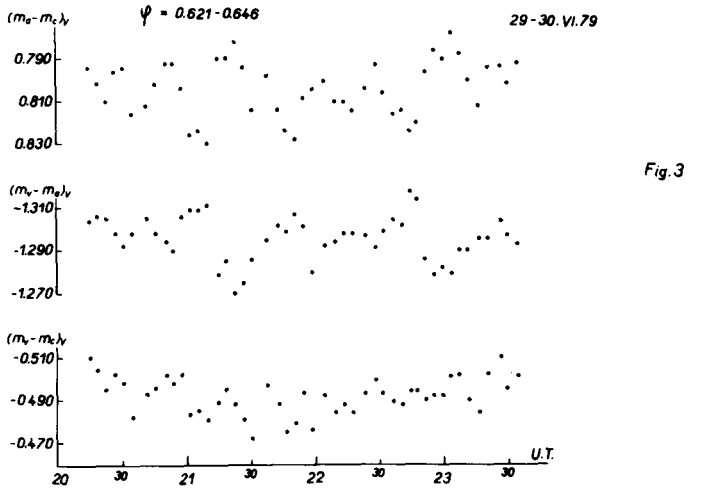

Fig. 3

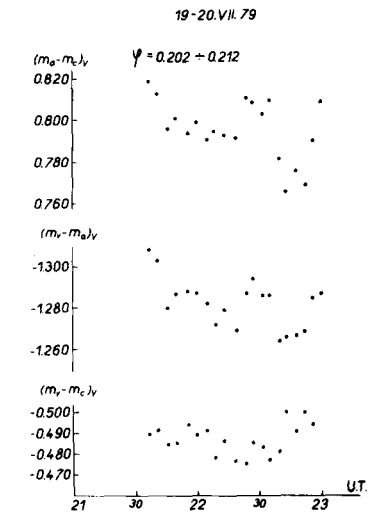

Fig. 4

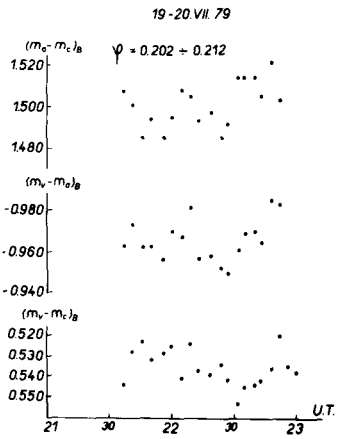

Fig. 5

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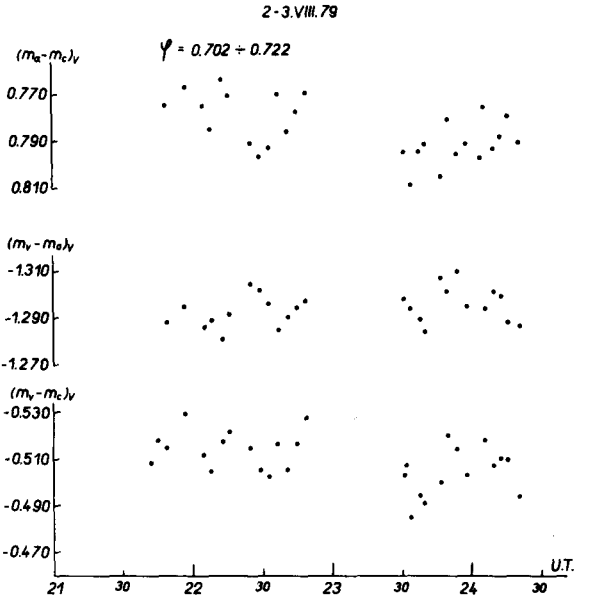

Fig. 6

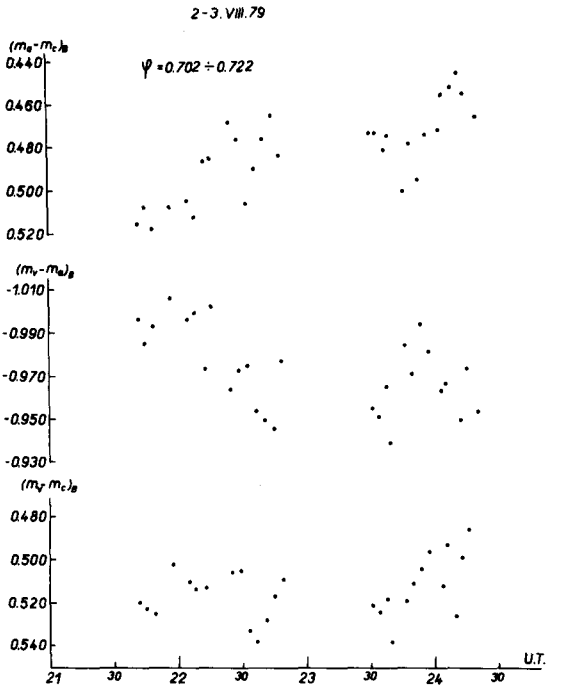

Fig. 7

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In conclusion, we find that the amplitude of possible, irregular fast light fluctuations of Cyg X-1 does not exceed $0^m.04$ in V and B, at least at the time of our observations.

It would be desirable:

1) To carry out further, accurate photoelectric photometry of star "a" in order to study the nature of its variability. Similarly, a spectroscopic study would be useful;
2) To perform accurate, high-speed photoelectric photometry of Cyg X-1, continuously during one or more nights, for a further investigation of possibly present fast light fluctuations. It would be particularly desirable to do so when the star is in its high state.

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