HIGH SPEED PHOTOMETRY OF DWARF NOVA EX HYDRAE

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ABSTRACT

High speed optical photometric observations of the hard X-ray source EX Hya, carried out with the reflector of the Kavalur observatory are presented. The observations with time resolutions of 1 s or 2 s were made on four nights in March 1982 for a total duration of 6.8 ^{h}. Beautiful light curves that reveal fast flickerings and the 67 min oscillations are presented. A new ephemeris for the photometric period confirms the trend towards decreasing period on a time scale of $\sim 10^7$ years. We also show evidence for the presence of interpulses in the light curves between successive photometric maxima.

1 INTRODUCTION

The cataclysmic variable EX Hydrae has been known to be a spectroscopic and eclipsing binary with a period of 98^m. The observation of an additional optical and soft X-ray photometric period of 67 min makes it a unique object in the class of dwarf novae (Vogt et al., 1980, Kruszewski et al., 1981 and refs. therein). The amplitude of the 67 min oscillation is variable, even from cycle to cycle, ranging from 0.05 mag. to 0.9 mag., but the intensity between two adjacent maxima has been reported to be more or less at constant level. The orbital eclipses last for a few min. only and have variable width and shape. Flickerings in intensity have been reported throughout the orbital cycle. In order to confirm the 67 min photometric period and to search for additional periodicities in the system, we included EX Hya in our ongoing programme of optical monitoring of X-ray sources, the results of which are presented in this paper.

2 OBSERVATIONS

The observations were carried out during March 1982, with the 1 m reflector of the Kavalur observatory. A single channel photometer (Sharma et al., 1981) was used for the observations. The star was observed with integration time of 1 s or 2 s for about 6.8^h mostly in white light, with occasional measurements in U, B and V bands for magnitude determination.

A part of the data has been converted to 60 s integrations from which light curves (after subtracting the contribution due to sky background) have been derived (see Figs. 1-4). The vertical lines marked in Figs. 3 and 4 show the maxima of the 67 min period. An examination of Fig. 4 reveals the existence of smaller peak ("interpulses") around $20^h\ 04^m$ UT and $21^h\ 08^m$ UT on March 14, 1982. They occur between the two maxima corresponding to the 67 min period and following the second maximum.

Observations with high time resolution (2 s), shown in Fig. 5, exhibit the rich variety of flickers and beautiful triangular-shaped flares in the light curves of EX Hya. Fig. 6 shows a small portion of the high time resolution data obtained on March 14, corresponding to the first maximum of Fig. 4. It shows that there are multiple peaks (at least four of them) during the maximum around $19^h\ 45^m$ UT as well as during the "interpulse" around $20^h\ 04^m$ UT. The maximum amplitude of the oscillation in this cycle is $\sim$1.1 mag.

In order to evaluate the secular nature of the 67 min period, we have plotted in Fig. 7 the O-C deviations between the Observed and Calculated times of the photometric maxima as a function of cycle number, E. The data other than ours have been taken from Kruszewski et al. Using our data on the times of photometric maxima, together with those of Vogt et al., Sterken et al., (1982) and Gilliland (1982) we derive a new ephemeris for the photometric maxima as

$$HJD\ (max) = 2437699.890436 + 0.046546581 * E - 9.7\times10^{-14} * E^2$$

The time scale of the observed decrease in the 67 min period is then given by $T = P/\dot{P} = -8.3\times10^6$ yrs.

4 DISCUSSION

Modulation of soft X-rays at the photometric period has been ascribed to the rotation of the white dwarf in the binary system. The secular decrease in this rotation period on a time scale of $\sim 8\times10^6$ yrs can then be due to accretion torques acting on the white dwarf in the system. The spin-up rate due to disc accretion on a rotating white dwarf is given by (Warner, 1983)

$$\dot{P}/P = -1.5\times10^{-7}\ (P/10^3 s)\ (L/10^{34}\ erg/s)^{6/7}\ yr^{-1}$$

For $P = 4020$ s and $L \sim 6\times10^{33}$ erg/s (Bath et al., 1980), we get $\dot{P}/P = -3.9\times10^{-7}\ yr^{-1}$ which is in reasonable agreement with the value of $-1.2\times10^{-7}\ yr^{-1}$, derived earlier.

The emission of soft X-rays with a period of 67 min appears to suggest that the white dwarf in EX Hya is magnetised and that the accreted matter is being channelled to the magnetic polar caps by the field lines. Unfortunately, however, the expected circular or linear polarisation of optical light has not been observed in the system, which may be indicative of a weak magnetic field. The spectroscopic data on EX Hya (Gilliland, 1982) indiate, on the other hand, an additional period of 33.5 min. Our observation of interpulses (in Fig. 4) following the maxima seems to provide the first evidence for the presence of such a period in photometric data. If confirmed by further observations, this result will help classify EX Hya as an intermediate polar with greater confidence. We have in Fig. 8 a replot of Fig. 5 for a duration of $\sim$4 min, wherein the peaks of 5 maxima from Fig. 5 are superimposed. This clearly indicates a new period of $\sim$165 s in the light curves obtained on March 2, 1982, which may be due to coherent buildup of instabilities in the accretion disc.

5 CONCLUSIONS

We have presented high time resolution measurements of the optical light variations of EX Hya. The light curves reveal a rich variety of shapes and amplitudes in the flickerings on time scales of minutes and confirm the 67 min photometric oscillations with maximum amplitudes of $\sim$1.1 mag. A new period of $\sim$165 s has also been occasionally observed. A new ephemeris for the photometric maxima, derived in this paper, indicates a secular decrease in the 67 min period on a time scale of $\sim 8\times10^6$ yrs. We show, in addition, the first evidence for the presence of interpulses between photometric maxima, a result that strengthens the arguments in favour of a magnetised white dwarf in EX Hya.

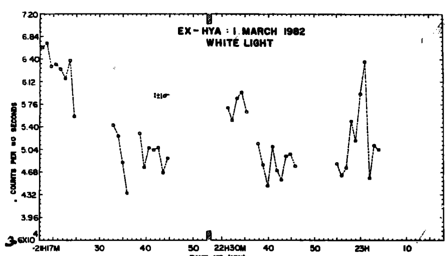

Figure-1

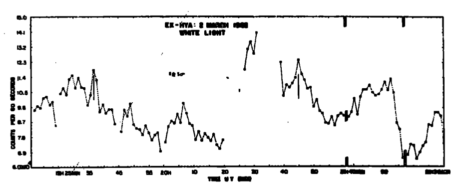

Figure-2

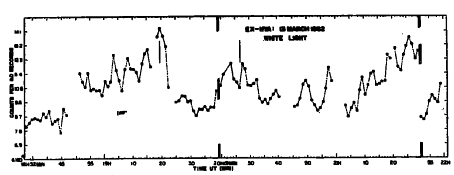

Figure-3

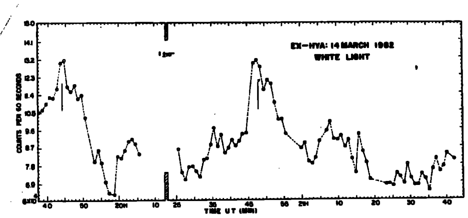

Figure-4

Figs. 1-4: Light curves of EX Hya in white light (60 s bins).

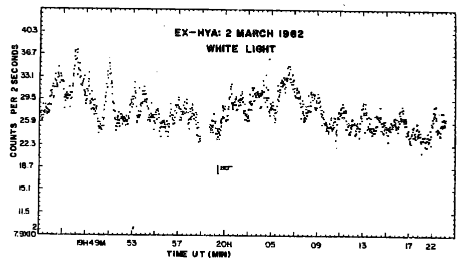

Figure-5

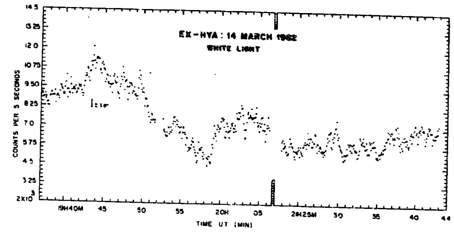

Figure-6

Figs. 5-6: High time resolution light curve of a part of Figs. 2 and 4, respectively.

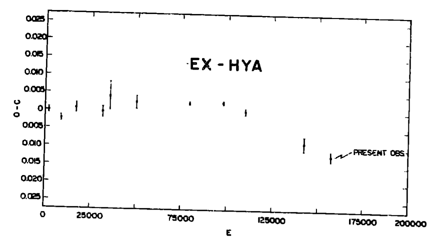

Figure-7

Fig. 7: O-C deviations vs E.

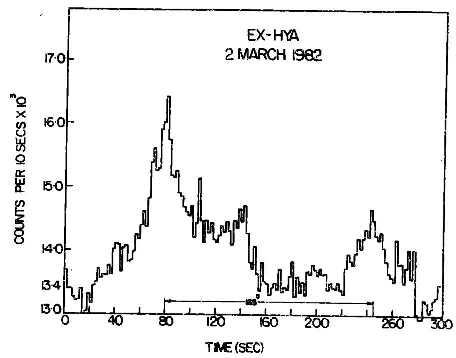

Figure-8

Fig. 8: Epoch analysis of 5 cycles of data from fig. 5, with the centres of peaks superposed.

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