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AN ANALYSIS OF LONG-TERM LIGHT CURVES OF FOUR NOVALIKE VARIABLES

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ABSTRACT

The long-term light curves of the novalikes TT Ari, KR Aur, AM Her and MV Lyr, were compiled and analysed for solar-like cyclical behaviour. The frequency analysis showed long-term cyclical modulations of the brightness of the stars, which can be ascribed to changes of the radii of the late type secondaries in order of $\Delta R/R \simeq 10^{-4}$-$10^{-5}$.

Key Words : accretion,accretion disks–binaries: cataclysmic variables–activity

I. INTRODUCTION

The main peculiarity of the observed long-term light curves of cataclysmic binaries is the existence of continuous cyclic fluctuations of the brightness in timescales from months to years. According to current ideas these light variations are due to variability of accretion disk luminosity, produced by changes in mass transfer from the late type secondary. In the last years (see Bianchini, 1992) the presence of solar type cycles in the secondaries of cataclysmic binaries has been assumed as a possible reason for the variations in the mass transfer rate. Warner (1988) and Bianchini (1988, 1990) showed that these cycles could be detected through investigations of the changes of quiescent luminosity, dwarf nova outburst intervals and orbital periods, as well as the behaviour in the dips observed in novalikes. In the polars, the presence of "swinging dipole" mechanism (Andronov 1987) has been proposed also as a reason for cyclic variations of the mass transfer rate. We report here results from analysis of long-term light curves of VY Scl type novalike systems TT Ari, KR Aur, MV Lyr and of the polar AM Her.

II. DATA AND DATA ANALYSIS

On a basis of our own photographic and photoelectric observations and data from literature the long-term light curves of the stars were compiled. We analysed the quiescent luminosity (high state) and, separately, dips luminosity including intermediate and low states using the period dispersion minimization method described by Stellingwerf (1978). We averaged the data using moving average. The smooting windows were equal to one day, one year and 1000 days.

III. RESULTS AND DISCUSSION

TT Ari. Analysis of all three average light curves gave 6 yr, as well as 5 yr periodicities in high state luminosity. The sinusoidal fits with these periods and peak to peak amplitude ~0.033 mag equaly well describes the 1000 days mean light curve (Fig.1). Consequently the available data didn't enable us to prefer anyone of them. Fig.1 shows an overall slow decreasing of brightness and superimposed cyclical behaviour. Peak corresponding to 392^d period is seen in θ-statistics of night mean light curve. The dips' analysis confirmed 12.6 yr cycle found by Bianchini (1990).

KR Aur. In the high state luminosity KR Aur showed 8.16 yr cycle as well as a clearly seen cycle with duration 250-300 days. The high state magnitudes averaged over 1000 days and sinusoidal fit with 8.16 yr period and amplitude 0.38 mag are shown in Fig.1. Frequency analysis of annual mean curve in the intermediate and low states gave a mean cycle from 3.4 yr for the dips and 10.1 yr for the dips at low state only .

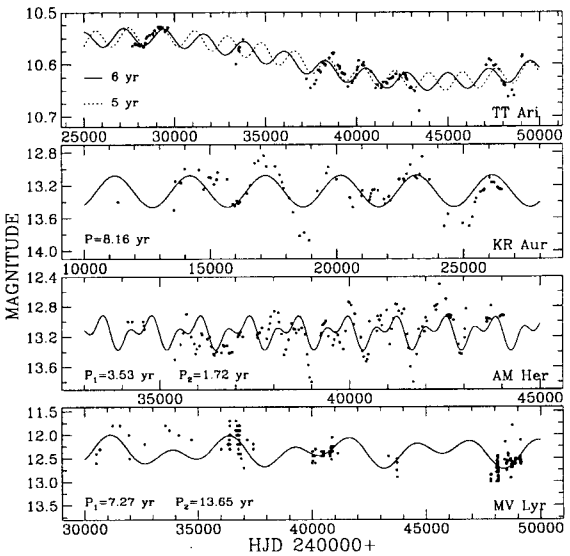

Fig. 1.— The high state mean light curves of TT Ari, KR Aur, averaged over 1000 days, AM Her, averaged over a year and MV Lyr, averaged over a day and the best fit to them

AM Her. The long-term behaviour of AM Her during 66 years is characterised with a 30 years interval of predominant active state since year 1951 and two inter-

vals, before and after it, of predominant intermediate or low state. All three intervals were analysed separately. The investigation of night mean luminosity in high state revealed variation with periodicities 3.53 yr, 1.72 yr and 300 days. The best fit to the annual mean magnitudes was obtained using two sinusoids with periods P_1=3.53 yr and P_2=1.72 yr and amplitudes 0.28 mag and 0.24 mag respectively (Fig.1). Frequency analysis of two other parts of the curve shows strong peak corresponding to period of 5.38 yr. In the Fig.2 we presented annual mean B magnitudes and sinusoidal fit with this period. It is seen that star's brightness after 1981 is modulated with shorter, ~1.7 yr, period. The same modulations could be seen in the part of the curve before 1951 which is enough well completed.

MV Lyr. The light curve of the star is not enough well complete at present. Because of this we analysed only high state luminosity and found as most probable 13.56 yr, 7.27 yr, 340 days and 321 days cycles. The best fit to the high state light curve was obtained using two sinusoids with periods $P_1 = 13.56$ yr and $P_2 = 7.27$ yr and amplitudes 0.34 and 0.49 mag (Fig.1).

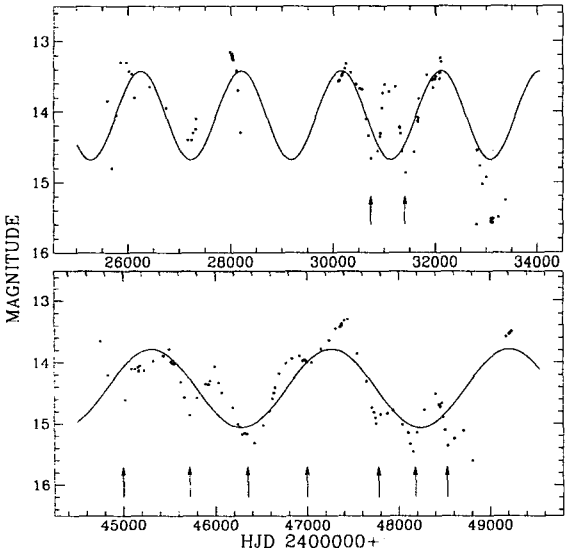

Fig. 2.— Annual mean B magnitudes in AM Her dips state (points). Solid line present sinusoidal fit with period 5.38 yr. The arrows mark the minima of 1.7 yr modulations.

Our results showed long-term cyclycal modulations of the brightness in timescales of years for all four novelikes. According frequency analysis cycles exist both in high and low state. Duration of the cycles is in the interval of values for CVs given by Warner (1988) and Bianchini (1992) and for single stars given by Wilson (1978). We estimated the changes of the radii of the secondaries in high state using Eq.19 in Warner (1988). They are in order of $\Delta R/R \simeq 10^{-4}$-$10^{-5}$. These results coincide with Gilliland's (1981) values for changes of solar radius and Warner's (1988) estimations of changes of the radii of other CVs. We didn't exclude the possibility that high and dips' states are parts of a longer, about a few decades, cycle, as well as the change of the duration of the 11 yr-like cycles in case of transition from high to low state.

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