Idling magnetic white dwarf in the synchronizing polar BY Cam. The Noah-2 project

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Abstract: A multi-color study of the variability of the magnetic cataclysmic variable BY Cam is presented. The observations were obtained at the Korean 1.8 m and Ukrainian 2.6 m, 1.2 m and 38 cm telescopes in 2003-2005, 56 observational runs cover 189 hours. The variations of the mean brightness in different colors are correlated with a slope $\frac{dR}{dV} = 1.29(4)$, where the number in brackets denotes the error estimates in the last digits. For individual runs, this slope is much smaller ranging from 0.98(3) to 1.24(3), with a mean value of 1.11(1). Near the maximum, the slope becomes smaller for some nights, indicating more "blue" spectral energy distribution, whereas the night-to-night variability has an "infrared" character. For the simultaneous UBVRI photometry, the slopes increase with wavelength from $\frac{dU}{dR} = 0.23(1)$ to $\frac{dI}{dR} = 1.18(1)$. Such wavelength dependence is the opposite of that observed in non-magnetic cataclysmic variables, in agreement with the model of cyclotron emission. The principal component analysis shows two components of variability with different spectral energy distributions (with a third at the limit of detection), which possibly correspond to different regions of emission. The highest peak in the scalegram analysis corresponds to the 200 min spin variability, its quarter and to the 30 min and 8 min QPOs. The amplitudes of these components are dependent on wavelength and luminosity state. The light curves were fitted by a statistically optimal trigonometrical polynomial (up to 4th order) to take into account a 4-hump structure. The dependences of these parameters on the phase of the beat period and on mean brightness are discussed. The amplitude of spin variations increases with an increasing wavelength and with decreasing brightness. The linear ephemeris based on 46 mean minima for 2003–2005 is $\text{HJD} = 2453213.010(3) + 0.137123(3)E$. The extensive tables of the original observations and of results of analysis are published in an electronic form. The nearby star GSC 4081-1562 was found to be an eclipsing red variable.

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1. Introduction

Cataclysmic variables are close binaries consisting of a red dwarf which is filling its Roche lobe, and a white dwarf. Accretion structure is strongly dependent on the characteristics of the flow as well as on the magnetic field of the compact star (see e.g. monographs by Warner [1] and Hellier [2]).

The object BY Cam (H0538+608) was discovered as an X-ray source by Forman et al. [3]. Remillard et al. [4] classified it as an AM Herculis-type system. Mason et al. [5, 6] provided near simultaneous polarimetry and phase-resolved spectroscopy and noticed extreme variations in the accretion geometry. Andronov and Fuhrmann [7] suggested that these variations are due to a small asynchronism between the spin and orbital rotation of the magnetic white dwarfs. This implies that there are slow periodic changes to the magnetic axis of the white dwarf (and corresponding changes to the accretion structure) in respect of the red dwarf with a period of 14.52 [8]. These changes are sometimes called "idlings" (or alternately scrollings or slewings).

In classical polars, the white dwarf is synchronized with the orbital motion, but the orientation of the magnetic axis may undergo cyclic changes in respect to the central line of the rotating cataclysmic binary system. Such changes were called "swingings" [9], contrary to the idlings in the asynchronous polars caused by different orbital- and spin periods of the white dwarf.

As the magnetic axis changes with respect to the secondary (donor star), the location of the accretion column above the white dwarf’s photosphere also change, as do other characteristics of the column.

From the cyclotron humps in the infrared spectra, Cropper et al. [10] estimated the magnetic field strength of the white dwarf to be 41 MGs, which is larger than the field strength in AM Her itself. This puts the object between relatively numerous groups of DQ Her-type stars (or intermediate polars) with rapidly rotating white dwarfs and the AM Her-type stars (or classical polars) which are synchronised [11]. Another asynchronous system was Nova Cyg 1975 = V1500 Cyg [12], thus the desynchronisation may be caused by a Nova outburst. Two more recent asynchronous polars are known (V1432 Aql and CI Ind). Sometimes these stars are called BY Cam-type stars [13, 14].

According to the last "live" electronic version of the catalogue (dated 01.09.2006) by Ritter and Kolb [15], the number of classical, asynchronous and intermediate polars is 77, 4 and 38 respectively, (from a total number of cataclysmic variables of 641). Asynchronous polars are relatively rare objects.

To study BY Cam, Silber et al. [8] have organized the Noah Project with a large flow of data obtained during more than 40 nights. Mason et al. [16] have succeeded in explaining contradictions between different periods using a model which alternates the active poles of the white dwarf. In this paper, we report results from the "Noah-2" project initiated to study different types of variability.