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Photometric Activity Cycles of UX Ari

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Abstract. New observations of the RS CVn variable UX Ari were carried out using Mini-MegaTORTORA (MMT-9) wide-field optical monitoring system and robotic wide-angle observation system in Zvenigorod observatory of INASAN. We defined more accurately the cycles of the long-period variability of UX Ari and noticed considerable changes in the shape of the power spectrum. In the long-term region we find three cycles at 5, 13.2 and 30 years. It is possible that some cycles are aliases but the most promising period of 30 years is clearly seen. We suppose that P(cycle) estimations for active stars over 10–50 years intervals should made it possible to build a new family of relations on diagrams P(cycle)/P(rot) versus 1/P(rot).

1. Introduction

UX Ari (HD 21242) belongs to the group of RS CVn variables—binary systems with a cool subgiant component with spots and chromospheric activity. The star is an object of long term detailed photometric investigations. After the discovery of nature of its variability based on strong calcium H and K lines (Popper 1956) the star was classified as a spectroscopic binary with a K0 subgiant primary (Aa) and G5 main sequence secondary (Ab) (Carlos & Popper 1971). Doppler imaging based on high resolution spectroscopy revealed a set of high- and low-latitude spots on UX Ari surface (Vogt & Hatzes 1991; Gu et al. 2005). Vogt & Hatzes (1991) also concluded that equatorial rotation rate is synchronized with the orbital one. Elias et al. (1995) modeled UX Ari light curve using small number of spots and detected a correlation between the radio emission flares and spot distribution on primary component surface between 1992 and 1993 using VLA and visual photometry data. They concluded that the flares originated from the regions close to spot groups. Just a two years later the largest flare of the star was observed in UV range (Henry & Hall 1997). The study of UX Ari radial velocity

(RV) gives a hint of a third component presence in the system. Using the CHARA six-telescope optical long-baseline array on Mount Wilson, California, (Hummel et al. 2017) obtained amplitudes and phases of the interferometric visibility on baselines up to 330 m in length, resolving the two components of the binary. Both interferometric visibilities and spectroscopic radial velocities are modeled with a spotted primary stellar surface using the Wilson-Devinney code. The equivalent spot coverage of the primary component was found to be 62% with an effective temperature 20% below that of the unspotted surface.

2. Observations

The results of photometric observations before 2002 are summarized in a review paper by (Aarum Ulvås & Henry 2003). Over the last 15 years the observations have not been done regularly. To fill this gap we first performed the analysis of photometric information for this object available in the imaging data archive of a Mini-MegaTORTORA (MMT-9) wide-field optical monitoring system (Beskin et al. 2017). As the object is too bright and saturates the typical deep survey images acquired with Andor Neo sCMOS detector, we developed the routine for the analysis of the photometry on average frames produced by averaging of every 100 frames acquired by Mini- MegaTORTORA during its high temporal resolution monitoring (0.1 s exposure each, which gives an effective exposure of 10 s for an average frame) and dominated by an uncorrected spatial inhomogeneities of CMOS detector sensitivity (Karpov 2019). As a result, we constructed the object light curve between August 2014 and February 2018, containing 432 V band measurements with the average accuracy better than 0.1 mag.

Moreover, in the September-October 2018 (between HJD 2458373 and 2458414) we made a set of UBV observations in Zvenigorod observatory of Institute of Astronomy of Russian Academy of Sciences using robotic system for monitoring of near-Earth space consisting of an OfficinaStellareRH-200 wide-field telescope, ASADDM 85 mount and a ScopeDome 2M dome. The telescope is equipped with a FLI Proline 16803 CCD with 4096x4096 9μm pixels. The exposure times were selected individually for every night and filter, and were between 20 and 60 s in order to bring the fluxes of object and comparison stars to the middle of detector dynamic range. Field of view was 3.5 x 3.5 degrees so that every frame contained a large number of comparison stars for differential photometry. Observational data were reduced by subtracting an average bias frame and dark current and normalizing to flat fields. Differential photometry was performed using MaxImDL software, and the accuracy of every single measurement was about 0.01 mag. To increase the photometric accuracy we co-added every 10 frames.

3. Results and Conclusions

Our new observations of UX Ari in V filter allowed us to refine the periods of a long term variability using the most complete data set containing 4399 measurements in V filter. Previous estimates of cycle periods made by Oláh et al. (2009) are around 3.6–4.6 years (also, the probable multiplicity of cycles are noted there). After taking into account our new observations (red dots in upper figure), we note a change in the shape of power spectrum. In the long-term region three cycles at 5, 13.2 and 30 years started

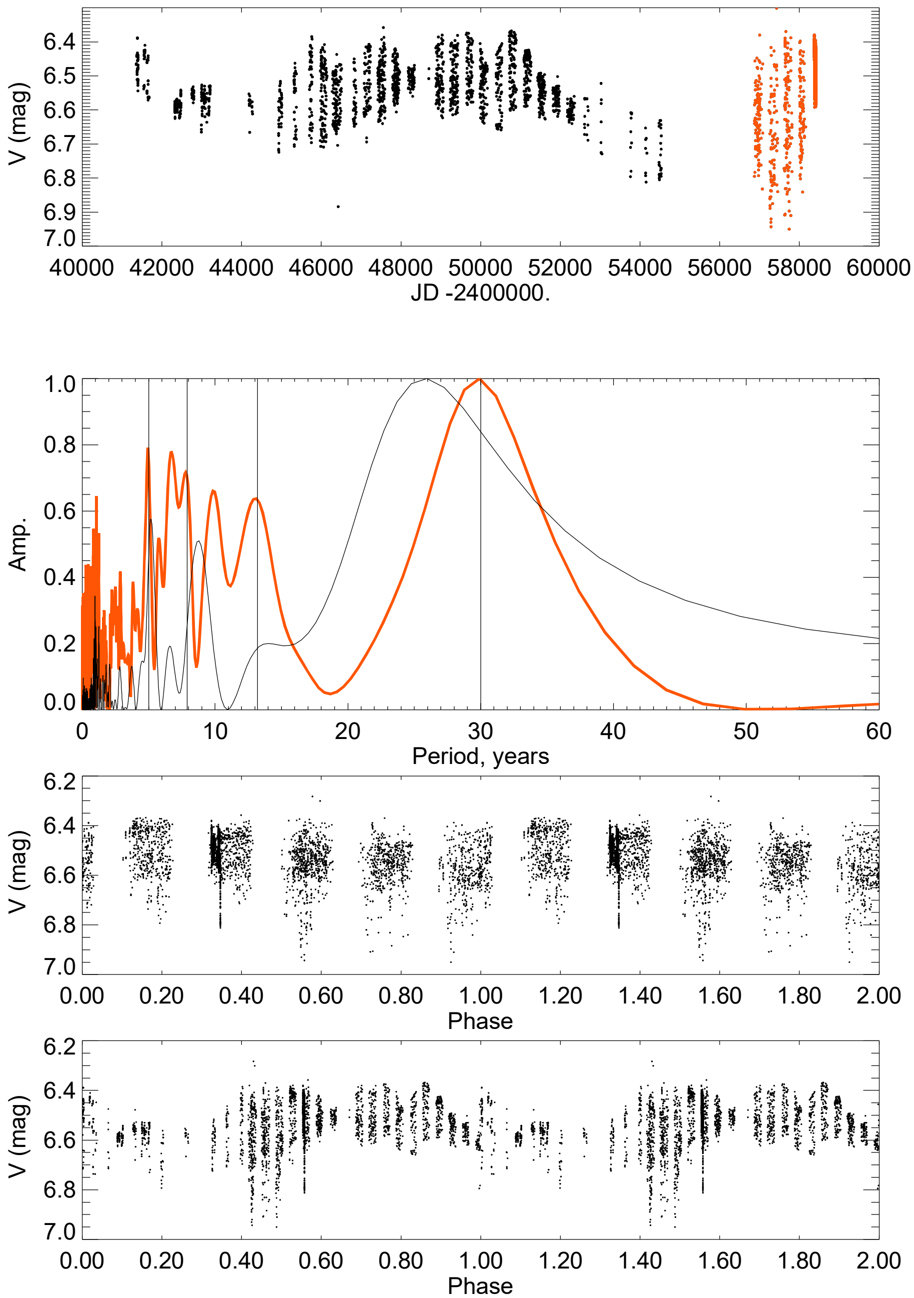

Figure 1. From top to bottom: Observations of UX Ari in V filter. Bright circles—our observations; Amplitude spectrum, the thick line - from the whole data set, the thin line—except our observations. Main cycles of a long-term variability are shown with vertical lines; The convolution of the available photometric observations with a period of 5 years; The convolution of the available photometric observations with a period of 30 years.

to appear. It is possible that some cycles are aliases, but the most promising period of 30 years is clearly seen in upper figure after addition of new observations. The folded light curves with periods of 5 and 30 years are shown in the lower part of figure. The P(cycle) estimations for active stars over 10-50 years intervals open the possibilities to build a new family of relations on diagrams like P(cycle)/P(rot) versus 1/P(rot), as well as to compare them with the hierarchy of cyclic variability of the Sun on long time intervals.

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