Contrib. Astron. Obs. Skalnaté Pleso **49**, 415 – 419, (2019)

Activity of rapidly rotating dwarf LO Peg an giant FK Com

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Received: October 31, 2018; Accepted: March 6, 2019

Abstract. In 2017-2018, using a robotic wide-field telescope at the Zvenigorod Observatory of INASAN, we carried out new observations of several active late type stars including a rapidly rotating dwarf LO Peg and a rapidly rotating giant – king of spin FK Com. New observations of stars carried out in the V filter allowed to obtain new data for the long-term variability cycles of these objects. Significant changes in the shape of the power spectrum were noted after taking into account our new observations. From the light curves we made restoration of the temperature inhomogeneities on stellar surfaces and determined positions of the active longitudes. The obtained measurements indicate the ongoing evolution of moving active regions and the switching phenomenon(flip-flop) of the positions of active longitudes for FK Com.

Key words: stars – activity – spots – cycles

1. Introduction

The robotic wide-angle monitoring system of the near-earth space of the Zvenigorod observatory of INASAN allows us to carry out photometric observations of cosmic objects according to the plan.

The system is equipped with the Davis Vantage pro2 meteorological observing station, the AAG CloudWatcher cloud cover detector and the Starlight Xpress all-sky camera. This configuration of the equipment, when used in conjunction with specially developed software, made it possible to create a robotic wide-angle optical system operating automatically. To control and obtain information from weather sensors, the software module Control program of weather conditions was designed.

The Veloce RH–200 telescope equipped with a set of Johnson UBVRI photometric filters was used. Observations were performed with the FliProline 16803 CCD with the camera chip size of 4096 x 4096 pixels, the pixel size was 9 x 9 μm. The exposure time (from 20 to 60 s) was chosen for each filter and night individually. The observed data was primarily processed that means subtracting the averaged bias frame, subtracting the dark current frame, and dividing the image frames into the flat field frames. The photometry of stars was conducted with the differential method. Frame reduction was conducted in the MaxImDL program package. The accuracy of a single measurement was about $0.^{m}009$.

During mentioned below photometric runs in 2017-2018 no flares on FK Com and LO Peg were recorded.

1.1. LO Peg

LO Peg is a K3 young star and belongs to the most studied fast-rotating stars of late spectral types (Karmakar et al., 2016). Its estimated age is 10 – 300 Myr. The star is a member of the AB Dor star group possessing a general spatial motion and for which there is an independent estimation of age, 30 – 150 Myr. The equatorial rotation speed of this star is 65 km s^{-1}, which suggests that it can be referred to ultrafast rotators of late spectral types. In recent years, numerous papers have been published on photometric and polarimetric studies of this star.

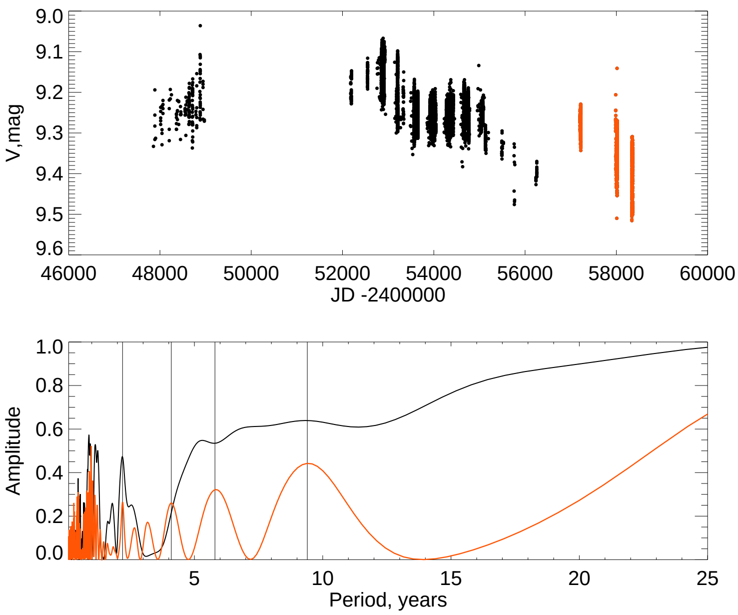

Figure 1. Top: observations of the star in the V filter (red dots are observations with a 20 cm telescope), the middle panel: amplitude power spectrum, the thick line – from the whole data set, the thin line –except for the observations of 2017. The cycles of a long–term variability of 2.2, 4.1, 5.8, and 9.4 yrs are shown with vertical lines.

New observations of LO Peg carried out in the V filter allowed the long – term variability cycles to be determined more precisely. Currently, the data set under consideration includes 15,251 single measurements. The amplitude power spectrum built from them is shown in the lower diagram (red line). We

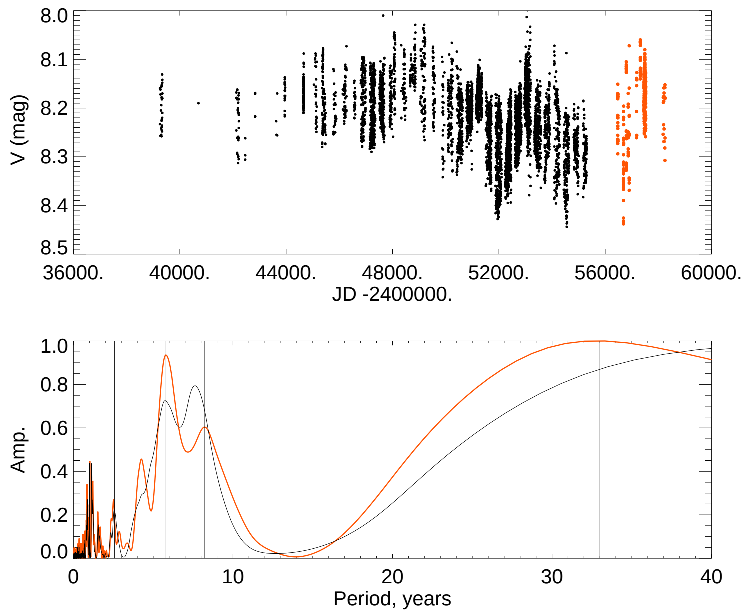

Figure 2. Top: observations of FK Com in the V filter (red dots are observations with a 20 cm telescope), the bottom panel: amplitude power spectrum, the thick red line – from the whole data set, the black thin line –except for the observations of 2017. The cycles of a long–term variability of 2.2, 5.5, 9.2 and 33 yrs are shown with vertical lines.

can notice significant changes in the power spectrum shape after taking into account the new observations of 2017-2018. In the region of the long – term variability cycles greater than 5 yrs, only two cycles appeared at 5.8 and 9.4 years (the power spectrum constructed from the data before our observations is represented in this figure by the black line). Our recent observations indicate that the brightness of the star has stopped to increase without reaching a level of stable brightness, and began to decrease again.

1.2. FK Com

FK Comae Berenices (FK Com, HD117555) is an ultra – fast spinning, heavily spotted, yellow giant. This single star is thought to be a recent binary merger, and is exceptionally active by measure of its intense ultraviolet (UV) and X-ray emissions, and proclivity to a flare (Puzin et al., 2016).

The spectral type of FK Com is estimated as G4III, the projection of the stars rotation velocity on the line of sight is 159 km/s. We present an analysis of new photometric observations of FK Com. Based on our new observational data and the data from the literature sources we performed an analysis of a complete set of the available photometric data.

From the calculated amplitude power spectrum we can notice significant changes in the power spectrum peaks in the region 6 – 8 years (the peak corresponding to the period of about 6 years became dominant) and in the region of the long – term variability peak of 33 years became visible.

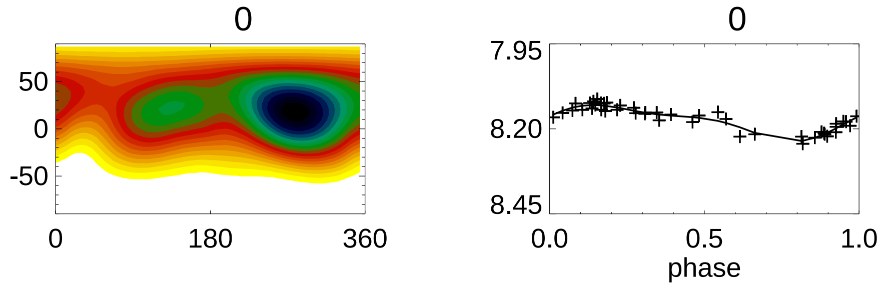

Figure 3. A spot filling factor distribution on FK Com in 2016 (left) and corresponding light curves (right). In the images the darker area implies a higher spot filling factor. Observed light curves are shown as crosses, and the fit as the solid line.

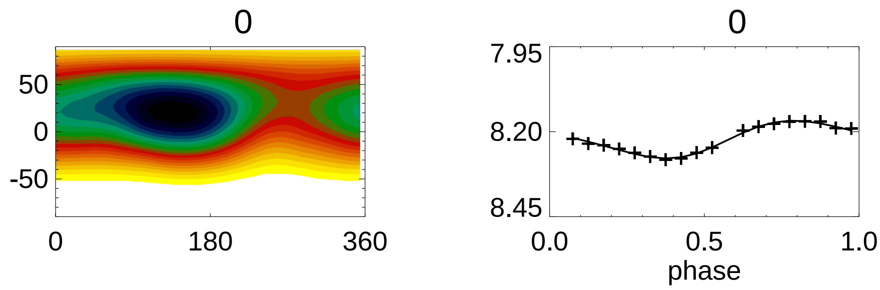

Figure 4. A spot filling factor distribution on FK Com in 2018 (left) and corresponding light curves (right).

From our observations obtained in 2016 and 2018 we made an analysis of surface temperature inhomogeneities of FK Com. To determine the large-scale spot distribution on this star, we apply an inversion technique to the light curves using a two-temperature approximation (Savanov & Strassmeier, 2008). In contrast to direct modelling of light curves, the inversions do not involve any assumptions about spot shapes, numbers, or latitudes. The inversion of the light curve results in the distribution of the spot filling factor over the stellar surface, i.e., a stellar image (Fig. 3 for 2016 and Fig. 4 for 2018). We adopted values of 5000 K and 4000 K for the photosphere and spot temperatures, respectively, like in our previous investigations (Puzin et al., 2016). We assumed that the star is spotless at V = 8.04 mag. The inclination of the rotational axis to the line of sight is chosen to be 50 degrees. From the stellar images, we recover spot longitudes with the maximum spot filling factor (see details in Puzin et al. (2016)). The accuracy of the spot longitudes depends on the broadness of the light-curve minimum and is on average 0.05 in phase. When two minima are seen in the light curves, two spot concentrations are recovered in the images (in our case one of them is strongly pronounced, the position of the second one is determined less accurately). Our map for observations in 2016 is constructed on the basis of 44 original measurements in filter V, while for the 2018 season 18 averaged values from 377 original measurements were used.

Data in Fig. 3 and Fig. 4 allow us to make a conclusion about the the transition of the star to a new stage of activity in the considered time interval. The shape of the light curve changed, and the dominating activity switched to the opposite longitude. Thus, there is a change in FK Com in positions of the active longitude equal to about 0.5 in phase units, occurred in interval between 2016 and 2018, but it still belongs to system A (a 9.5 year long cycle – Puzin et al. (2016)).

Acknowledgements. This work has been supported by a RFBR Grant 17-52-45048 Flares from F to M - type stars.

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