Photometric activity of the UX Ori type stars in the young cluster IC 348

Barsunova O.Yu.[1]*, Grinin V.P.[1], Sergeev S.G.[2], Shugarov S.Yu.[3,4], Efimova N.V.[1]

* monoceros@mail.ru
1 Central (Pulkovo) Astronomical Observatory of RAS, Russia
2 Crimean Astrophysical Observatory of RAS, Russia
3 Sternberg Astronomical Institute, Lomonosov Moscow State University, Russia
4 Astronomical Institute, Slovak Academy of Sciences, Slovak Republic

Abstract. We present results of the multi-year photometric (VRI) monitoring of six T Tauri stars in the young cluster IC 348. All targets demonstrate the UX Ori type activity. Three of them (V 712 Per, V716 Per, V909 Per) are the classical TTSs, three others (V695 Per, V715 Per, V719 Per) are the weak line TTSs. The light curves demonstrate the large diversity. In two cases we observed the combination of the UXOr type activity and periodic brightness variations similar to that observed in AA Tau by Bouvier et al. (1999). In one case we observed the very long (about 3 years) deep minimum with a sudden start and the same sudden end. The properties of the observed photometric activity and its origin are briefly discussed.

Observations

Optical observations were acquired between 2003 and 2019, using the 0.7 m telescope of the CrAO. The additional optical observations were acquired between 2009 and 2019, using the 0.5 m telescope of the Astronomical Institute of the Slovak Academy of Sciences. Depending on the brightness level of a star, the uncertainties in the V magnitudes ranged from 0.03^m (maximum brightness) to 0.15^m (minimum brightness). The uncertainties in R and I were, on average, no more than 0.03^m.

Results and Discussion

Results of the observations are presented in Fig. 1-5. The main part of them was published in our papers (Barsunova et al. 2013,2015, 2016; Grinin et al. 2018). In this poster we added the new data obtained with 0.5 m telescope and with 0.7 m telescope up to March 2019.

The light curves of all objects demonstrate complicated behavior: the low-amplitude oscillations observe on the background of the large-scale brightness variations (Fig. 1, 2). Our optical photometry of V695 Per, V715 Per and V716 Per confirms the presence of the low-amplitude periodic brightness variations reported earlier in other studies. The periods we have derived (Fig. 5, 6) are close to these detected earlier. This period was stable during the entire interval of our observations (about 16 years). But in cases of V715 Per and V716 Per the phased light curves vary slightly from year to year.

The analysis of color–magnitude diagrams (Fig. 3, 4) has shown variable circumstellar extinction to be the main source of the star's optical variability for the entire range of its brightness variations. It follows that the periodic brightness modulation of V695 Per, V715 Per and V716 Per is due to changes in extinction when the star is screened by the inner (warped) circumstellar disk, as occurs for AA Tau variables (Bouvier et al., 2007).

From 2013 to 2016 V719 Per (Fig. 2) had a deep eclipse during which the star's brightness fluctuated with an amplitude of about 2 mag. This eclipse may have been caused by some dense extended region at a considerable distance from the star. However, the amplitudes of Algol-like minima and long-lasting eclipse are comparable, meaning the level of scattered light remains the same. This suggests that the long-lasting eclipse is a composition of minima. Perhaps it is something like that we are seeing on the V712 Per light curve (Fig. 1), but the color-magnitude diagrams (Fig. 3) indicate that neutral dust particles were added to the line of sight like in case of CQ Tau (see Shakhovskoj et al., 2005).

For V695 Per, V715 Per and V716 Per the times of Algol-like minima do not correlate with the phase of the low-amplitude brightness variations (Fig. 5, 6). This indicates an absence of any physical relationship between these two mechanisms for the star's brightness variability. We suggest that the brightness minima can be caused by the temporary increase of the mass accretion rate onto the stars (see Grinin et al. 2018 for more detail).

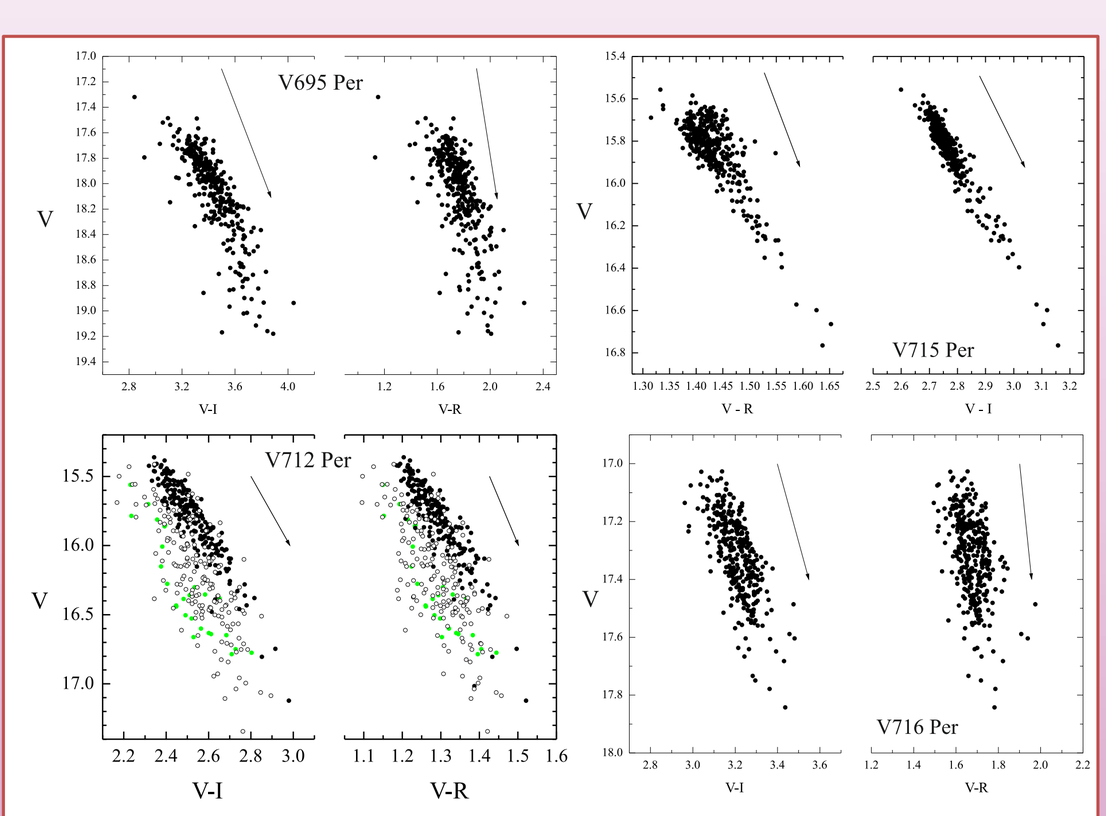


Fig. 3. Color–magnitude diagrams for V695 Per, V712 Per, 715 Per and V716 Per in the VRI bands. The green dots are the Gaia data. The open circles are the data from 2013 to 2019. The arrows are the direction of the standard reddening law.

Fig. 4. Color–magnitude diagrams for V719 Per and V909 Per in the VRI bands. The arrows are the direction of the standard reddening law.

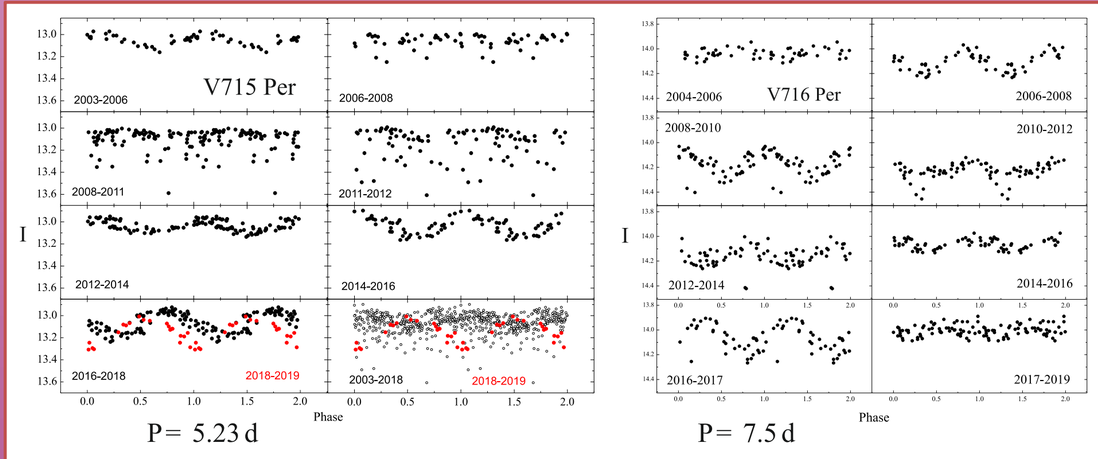


Fig. 5. The phase curves (I band) for V715 Per and V716 Per divided into separate observational seasons.

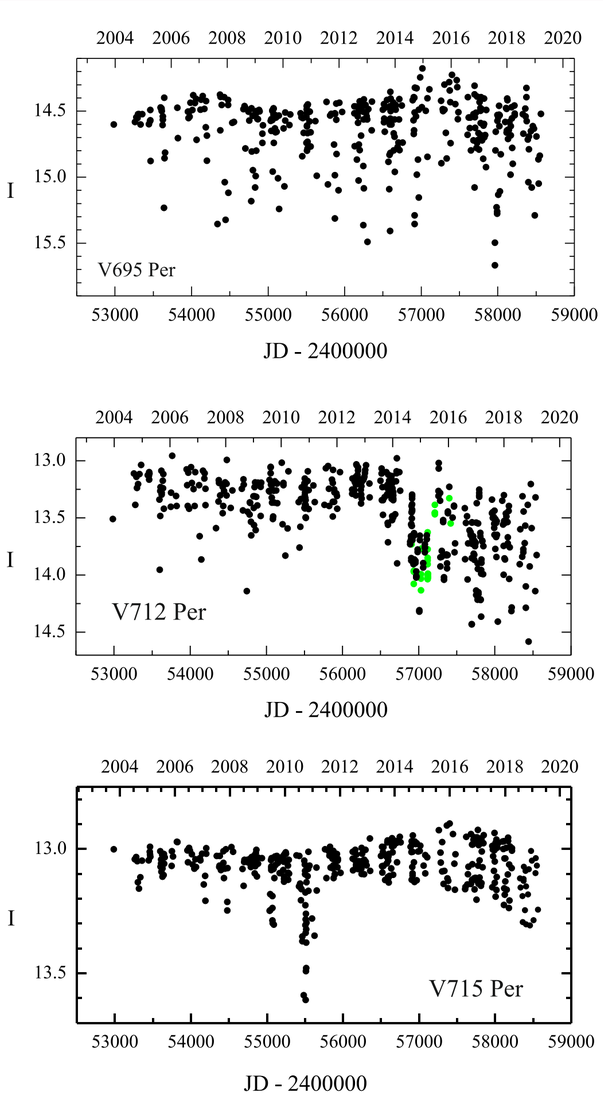


Fig. 1. I light curves of V695 Per, V712 Per and V715 Per for the entire interval of our observations (2003–2019). The green dots are the Gaia data.

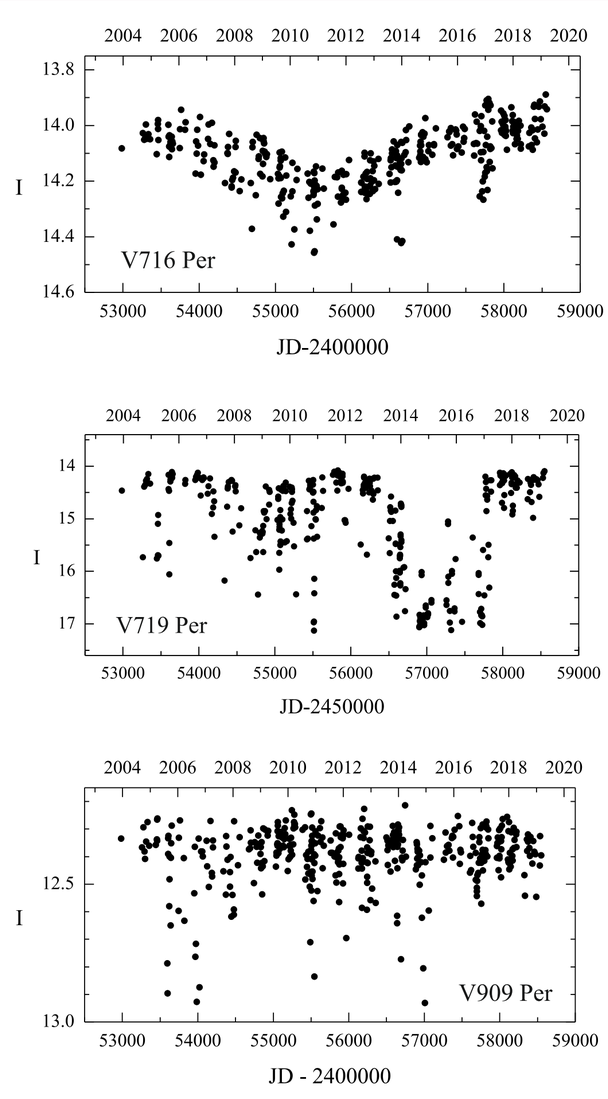
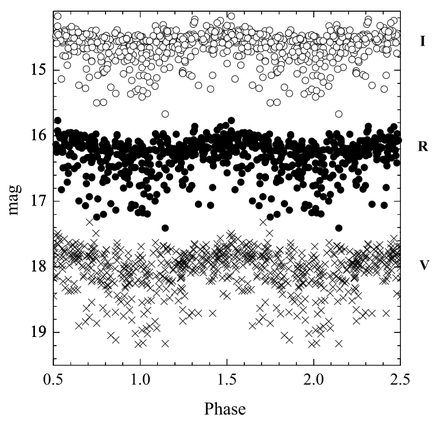


Fig. 2. I light curves of V716 Per, V719 Per and V909 Per for the entire interval of our observations (2003–2019).

Conclusion

Photometric activity of young stars such as AA Tau and UX Ori can be observed simultaneously in the same stars. It is obvious that the existence of such hybrid variability is possible only in the cold part of the UX Ori stars, in which the dust component of the disk is preserved up to the magnetosphere of the star.



P= 7.6 d

Fig. 6. Phase diagrams for V695 Per in the VRI bands.

Reference

Barsunova et. al., 2013, Astorphysics, 56, 345
Barsunova et. al., 2015, Astorphysics, 58, 193
Barsunova et. al., 2016, Astorphysics, 59, 147
Bouvier J. et al., 2007, Astron. Astrophys. 463, 1017
Grinin V.P. et al., 2018, Ast. Rep. 62, 677
Shakhovskoj et al., 2005, Astrophysics, 48, 135