

Long-term variability and outburst activity of FS Aurigae: further evidence for a third body in the system

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FS Aurigae:

- is a dwarf nova (Hoffmeister 1949);
- has a typical dwarf nova spectrum (Williams 1983);
- has the “usual” orbital period of 85.7 min defined from H α spectroscopy (Thorstensen et al. 1996);
- probably belongs to the SU UMa sub-class of dwarf novae.

The outlandish peculiarity of FS Aur:

- The existence of well-defined photometric optical modulations with a very coherent long photometric period (LPP) of 205.5 min that exceeds the spectroscopic orbital period (OP) by 2.4 times! (Neustroev 2002; Tovmassian et al. 2003);
- Tovmassian, Zharikov & Neustroev (2007) discovered a second long spectroscopic period (LSP) of 147 minutes. They showed that frequency of this new period is equal to the beat between the OP and LPP.

Possible causes of this puzzling behaviour:

- Tovmassian et al. (2003) concluded that the "usual" effects explaining photometric period that are longer than spectroscopic, can be effectively ruled out.
- A possible explanation might be a rapidly rotating magnetic white dwarf in FS Aur freely precessing with a period equal to the Long Spectroscopic Period.

Long-term variability of FS Aur

- Based on the short orbital period, FS Aur has been classified as a SU UMa star.
- Nevertheless, long-term monitoring of the system by several groups failed to detect any superoutburst in its light curve.
- Instead, this monitoring reveals a very long photometric period (VLPP) of ~ 900 days.
- Tovmassian et al. (2010) explain the latter by the result of eccentricity modulation of a close binary orbit induced by the presence of a third body on a circumbinary orbit.

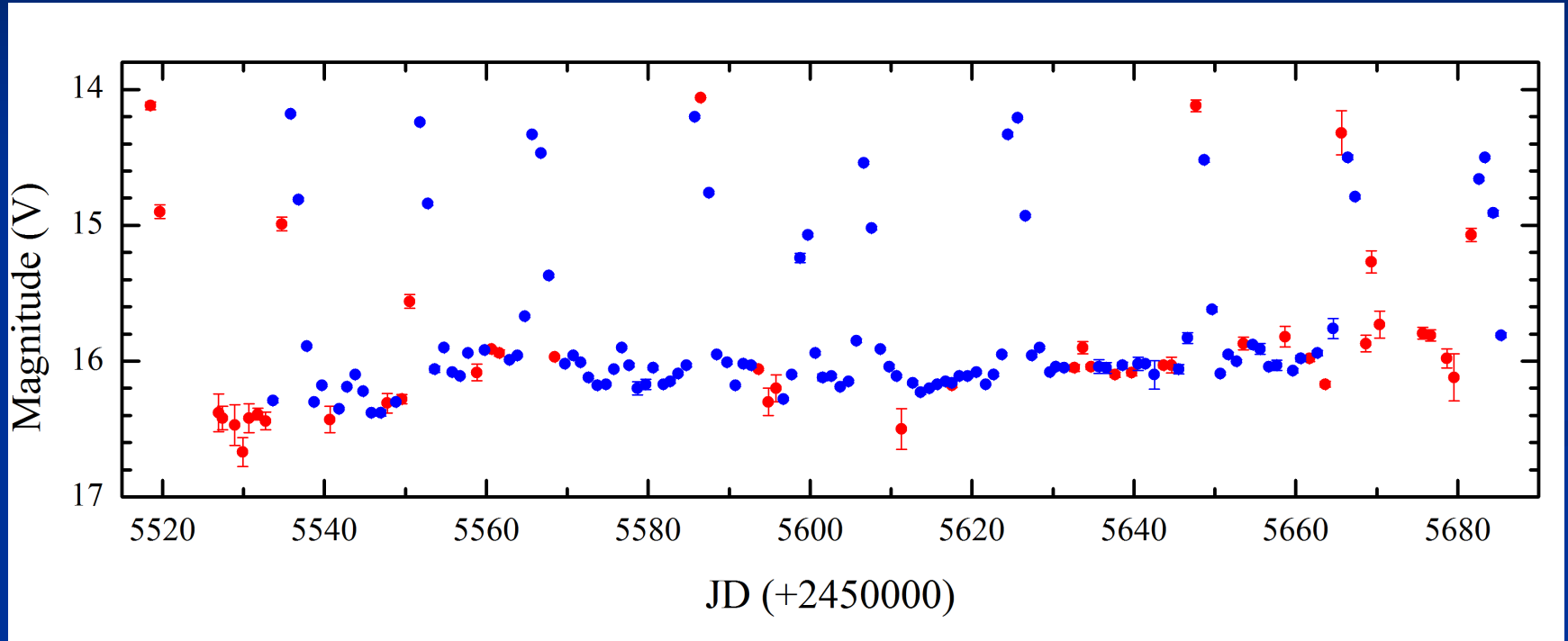
The 2010-2011 observing campaign

- more than 150 nights of photometry were taken:
 - more than 140 consecutive nights
 - 80 nights of time-resolved photometry
 - almost 14000 V-band data points were obtained
- 31 nights of time-resolved BVR_cI_c photometry
- Depending on the weather conditions, we monitored the star for 6-8 hours per night in the beginning of the campaign and for 3-4 hours in the end.

The 2010-2011 observing campaign

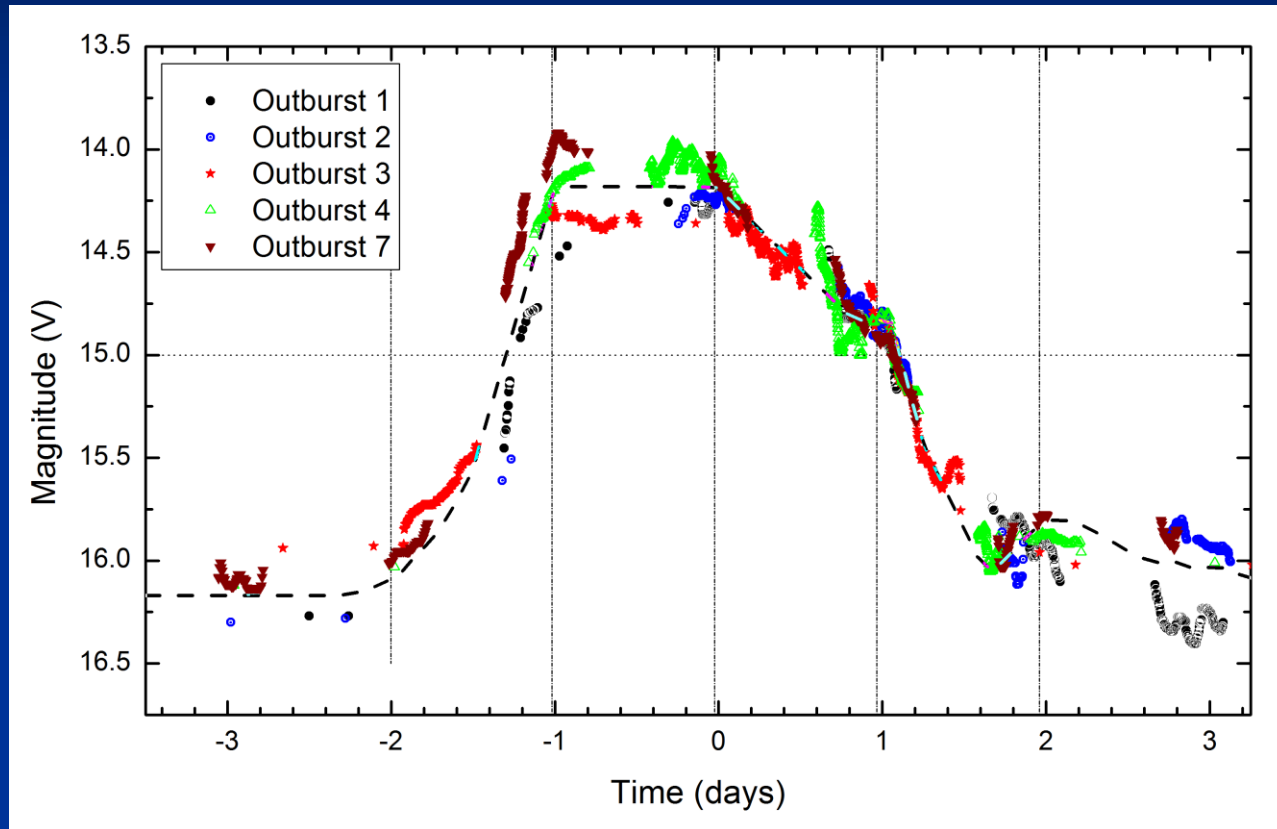
- 11 consecutive low-amplitude outbursts were observed
- We discovered prominent superhumps clearly seen in the light curve of FS Aur after all outbursts.

The 2010-2011 observing campaign



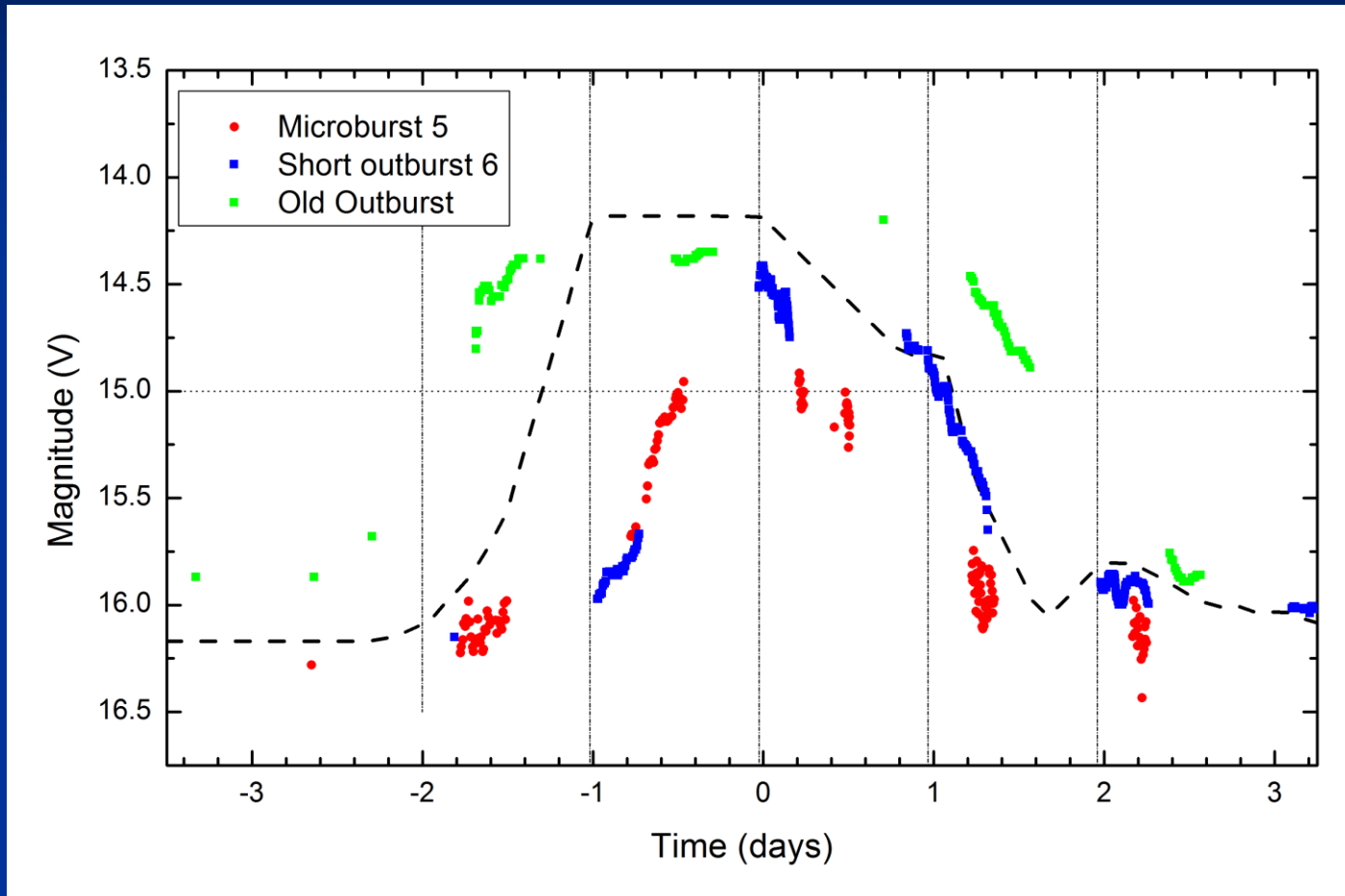
Light curve of FS Aur. Each point is the 1-day average of observations. Blue points represent the observations obtained by the authors, while the red points represent the AAVSO observations.

The 2010-2011 observing campaign



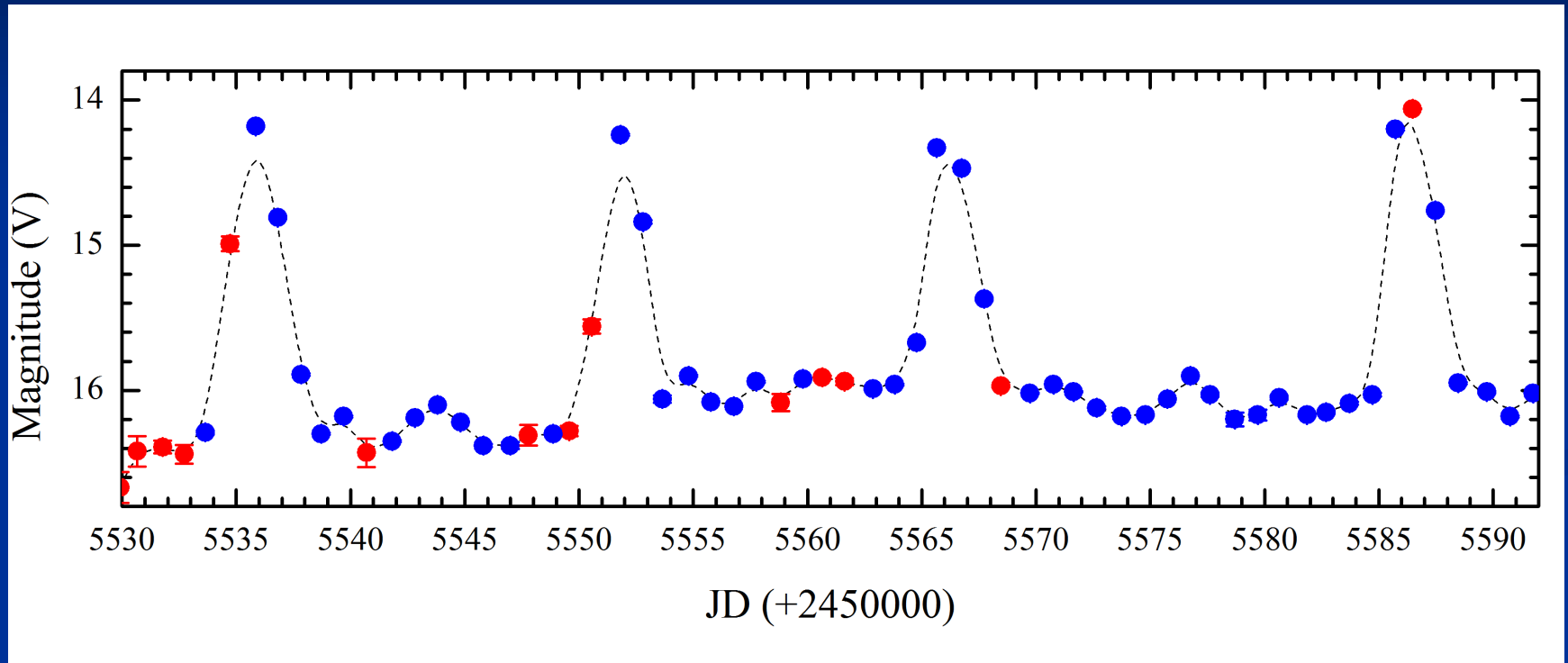
The mean outburst profile of FS Aur is an average of 5 best covered outbursts.

The 2010-2011 observing campaign



Anomalous outbursts.

The 2010-2011 observing campaign

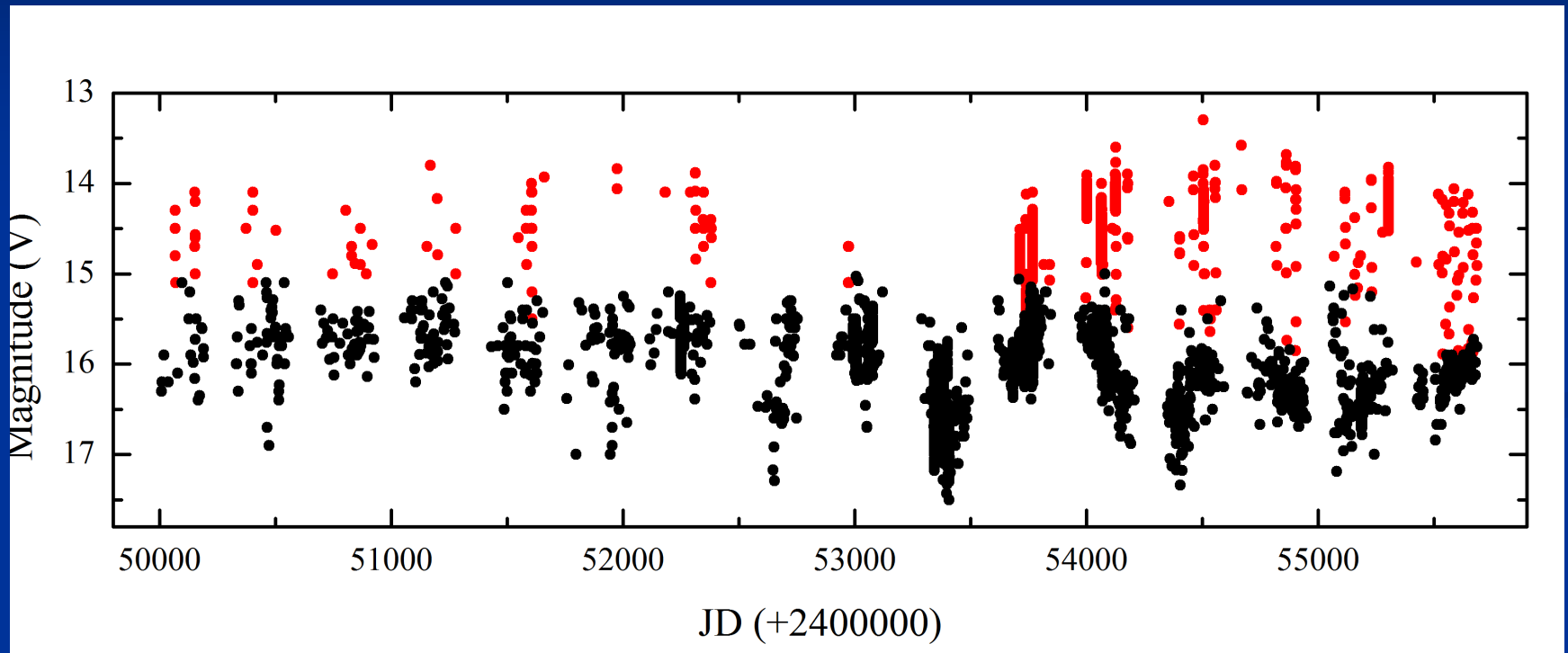


The zoomed light curve of FS Aur. Note the strong variability during the quiescent state.

The peculiarity of FS Aur:

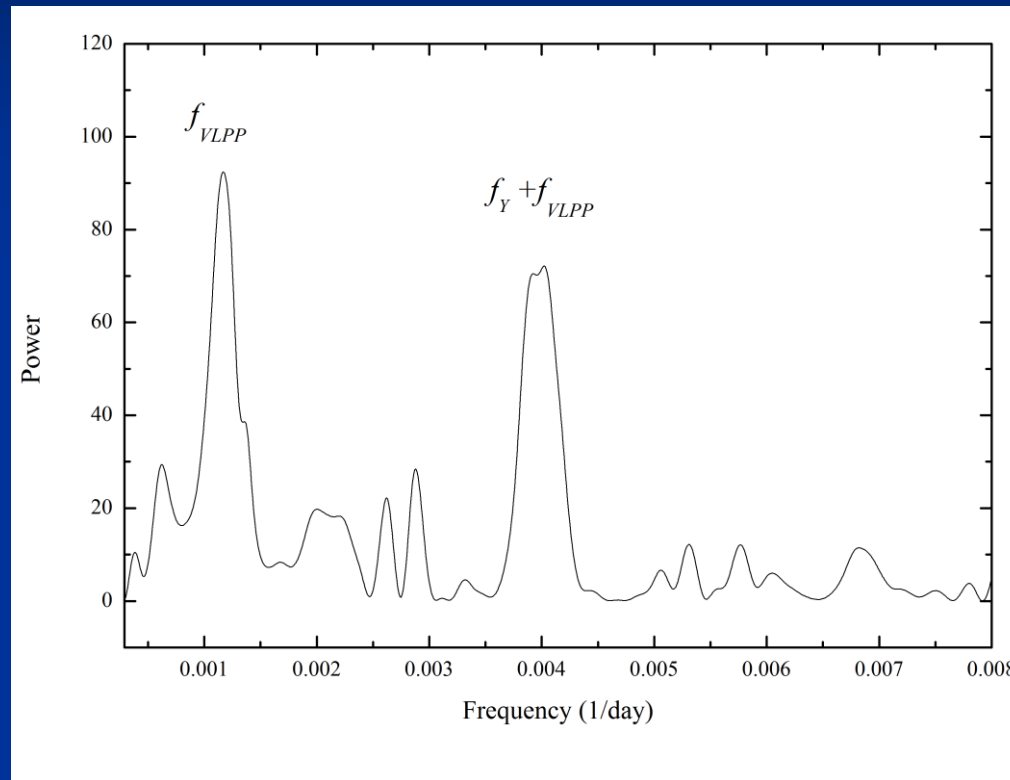
- FS Aur exhibits the strong variability during even the quiescent state;
- during the winter of 2010-2011, the average quiescent level increased $\sim 0.3-0.4$ mag.

The long-time photometric behaviour of FS Aur



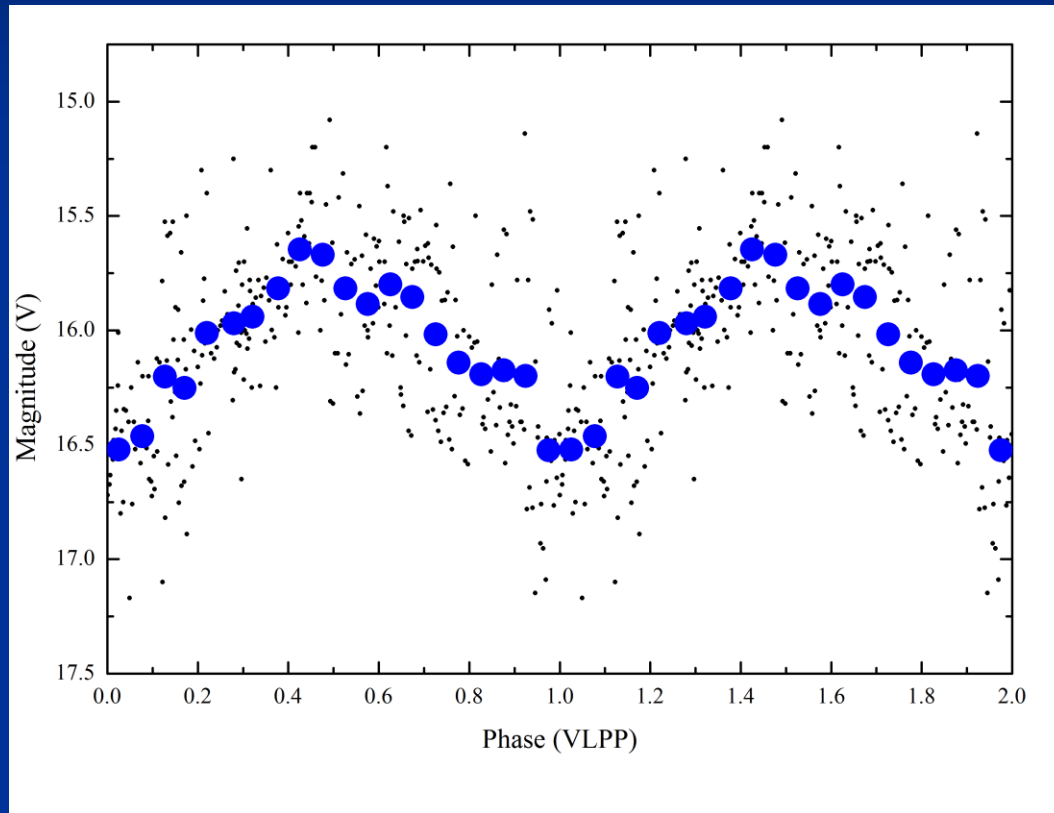
Long term light curve of FS Aur. The red points correspond to outbursts.

The long-time photometric behaviour of FS Aur



The power spectrum of the quiescent light curve of FS Aur. The strongest peak at $f_{VLPP} = 0.0011$ 1/day corresponds to the Very Long Photometric Period (VLPP). The second highest peak is an alias created by beat between f_{VLPP} and f_{Year} .

The long-time photometric behaviour of FS Aur



The long term quiescent light curve of FS Aur folded with the 893 day period

The long-time photometric behaviour of FS Aur

- FS Aur exhibits the variable (periodic?) mass-transfer rate.
- The variable mass-transfer rate can be caused by the presence of a third companion of a compact binary.

FS Aur is a triple system

- Mazeh & Shanan (1979) and Bailyn (1987) have shown that a third star orbiting a close binary modulates the binary eccentricity and the inner binary separation (even for a circular orbit of the binary system!).
- The behaviour of such systems is extremely sensitive to this separation, since small changes in the binary separation can cause drastic changes in the mass-transfer rate.

FS Aur is a triple system