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

by

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Essential Tools

1 Introduction

FS Aurigae represents one of the most unusual cataclysmic variable (CV) to have ever been observed. The system is famous for a variety of uncommon and puzzling periodic photometric and spectroscopic variabilities which do not fit well into any of the established sub-classes of CVs. The outlandish peculiarity of FS Aur is the existence of well-defined photometric optical modulations with the amplitude of up to ~ 0.5 mag and 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). Also, Tovmassian et al. (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, and the precession of a fast-rotating magnetically accreting white dwarf (WD) can successfully explain these phenomena.

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. In order to better understand the outburst activity of FS Aur, during the winter of 2010-2011 we have observed 11 consecutive low-amplitude outbursts (≤ 2 mag) and discovered prominent superhumps clearly seen in the light curve of FS Aur after all outbursts. We report here preliminary results of these observations.

2 The 2010-2011 observing campaign

During the winter of 2010-2011 we have initiated and conducted an observing campaign, lasted more than 140 consecutive nights. The bulk of these data will be discussed elsewhere. Here we concentrate on an outburst activity and long-term variability of the system.

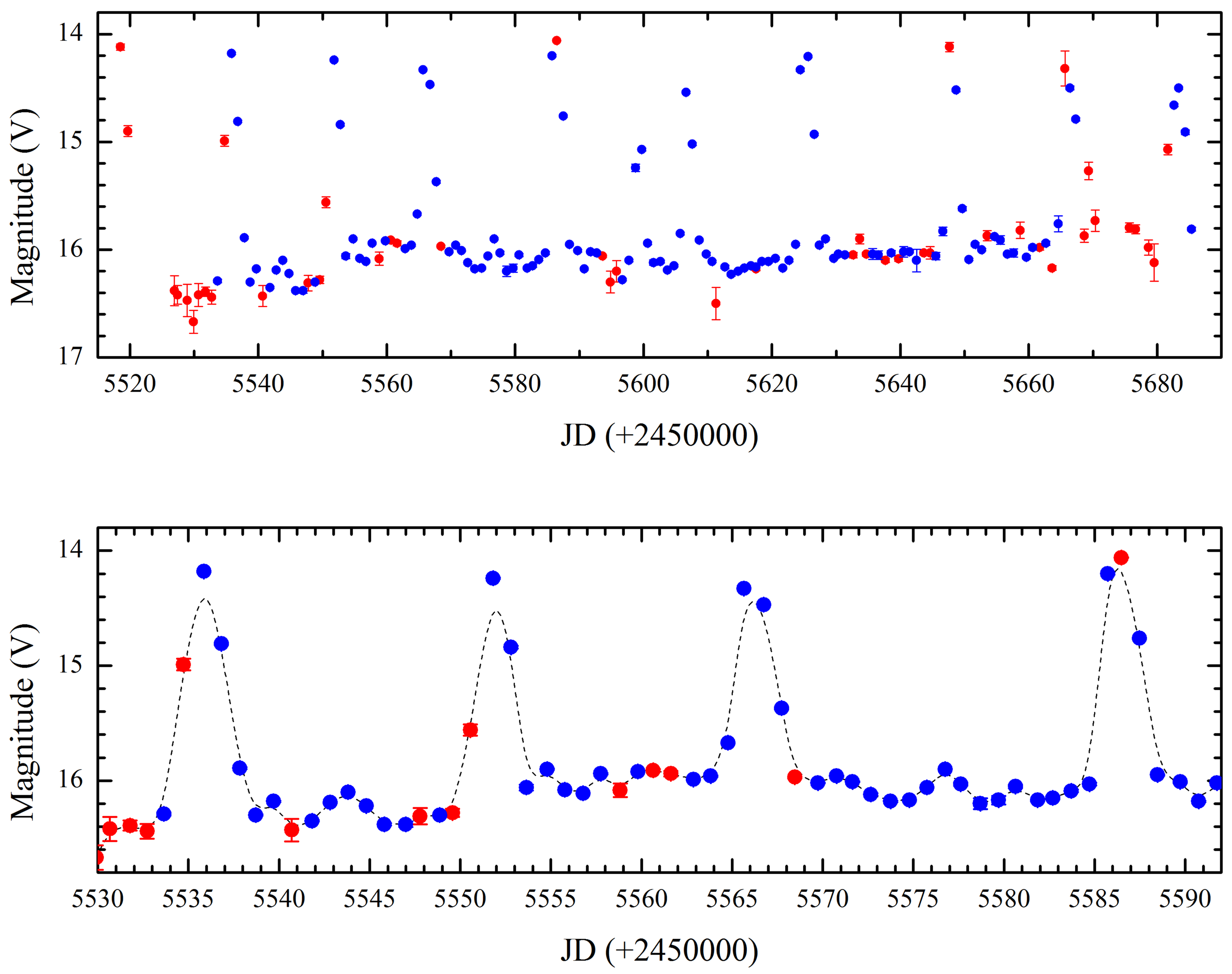

Figure 1: Light curve of FS Aur, from the 2010-2011 observing campaign. Each point is the 1-day average of observations. Blue points represent the observations obtained by the authors, while the red points represent the AAVSO observations. The upper panel shows the whole light curve while the lower panel displays the zoomed light curve. Note the strong variability during the quiescent state.

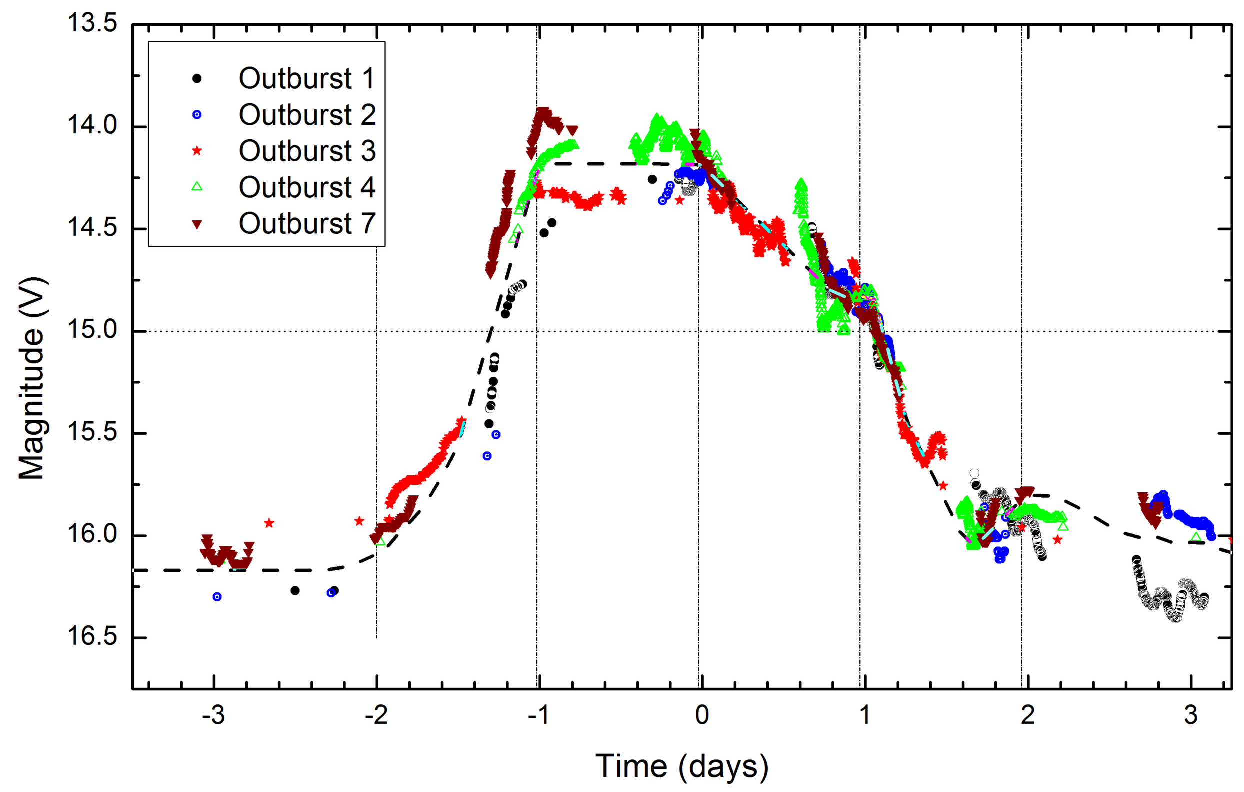

Figure 2: The mean outburst profile of FS Aur is an average of 5 best covered outbursts.

The observations were conducted every clear night from November 26, 2010 until May 3, 2011. 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. Thus, more than 150 nights of photometry were taken (80 nights of time-resolved photometry), and almost 14000 V-band data points were obtained.

The typical accuracy of our measurements varied between 0.01 and 0.12 mag depending on the brightness of the object and the weather conditions. The median value of the photometric errors was 0.03 mag in the V filter. We formed 1-day averages of these observations to reduce the scatter from both random errors and stochastic and short-term variability. The whole and zoomed light curves from the observing campaign are shown in Figure 1. The mean outburst profile is shown in Figure 2.

We note that (a) FS Aur exhibits the strong variability even during the quiescent state; (b) during the winter of 2010-2011, the average quiescent level increased $0.3 - 0.4$ mag.

3 The long-time photometric behaviour of FS Aur.

In order to investigate the long-time photometric behaviour of FS Aur, we make use of observations collected and archived by the American Association of Variable Star Observers (AAVSO). For FS Aur, the database contains almost 14,000 observations obtained before 2010 December 1 and largely after 1995. We have chosen to work with the higher quality data taken after JD 2,450,000. For completeness, we also included our previous observations taken since 1995 (some 100 nights of time-resolved observations).

The light curve of FS Aur is very complex with large nightly variations sometimes exceeding 0.5 mag. Even with such a large spread, there are also obvious 2 magnitude dips in the average brightness of the system. The dips are sharp and the variability is not sinusoidal, but the succession of minima appears to be periodic (Figure 3).

The Lomb-Scargle periodogram is shown in Figure 4 (Left panel). The strongest peak at f_{VLPP} = 0.0011 $\pm$ 0.0002 1/day (893 days) corresponds to the Very Long Photometric Period (VLPP). The long term quiescent light curve of FS Aur folded with the 893 day period is shown in Figure 4 (Right panel).

4 Discussion

The mass-transfer rate is very sensitive to the Roche lobe size, which is proportional to the binary separation. In hierarchical triple systems, a third body can induce an eccentricity variation in an inner binary (Mazeh & Shaham 1979; Georgakarakos 2002, 2009). The long-term modulation is produced by the time-varying tidal force of the perturber upon the binary.

Thus, the long-term variability of FS Aur and the character of its outburst activity may be caused by variations in the mass transfer rate from the secondary star as the result of eccentricity modulation of a close binary orbit induced by the presence of a third body on a circumbinary orbit (Tovmassian et al. 2010).

5 References

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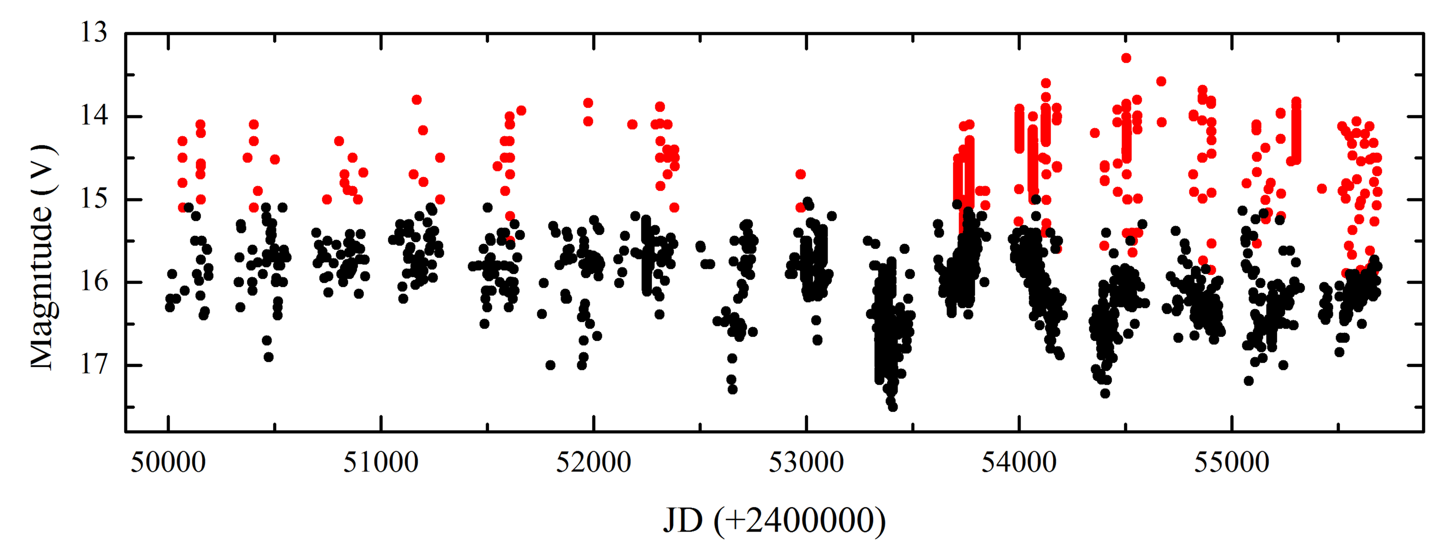

Figure 3: Long term light curve of FS Aur. The red points correspond to outbursts.

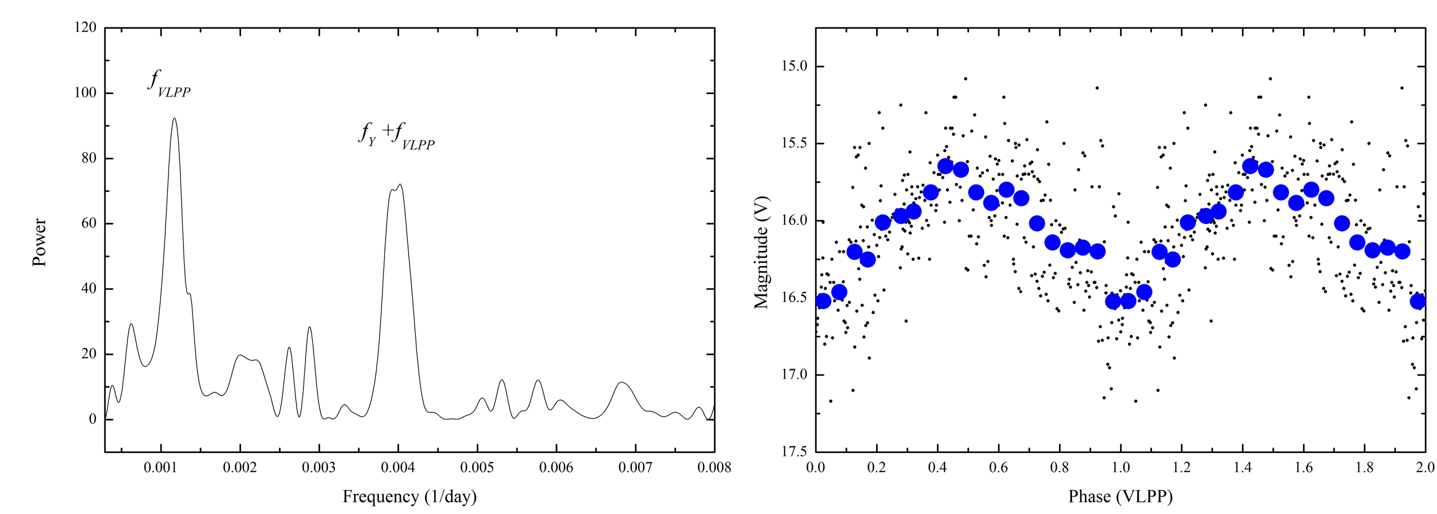

Figure 4: Left: The power spectrum of the quiescent light curve of FS Aur. The strongest peak at f_{VLPP} = 0.0011 $\pm$ 0.0002 frequency corresponds to the Very Long Photometric Period (VLPP). The second highest peak is an alias created by beat between f_{VLPP} and f_{Year}. Right: The long term quiescent light curve of FS Aur folded with the 893 day period.