Time-resolved flickering mapping of V2051 Ophiuchi

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Abstract. Although flickering is one of the fundamental signatures of accretion, it is also the most poorly understood aspect of the accretion processes. A promising step towards a better understanding of flickering consists in using the eclipse mapping method to probe the surface distribution of the flickering sources. We report on the analysis of light curves of the dwarf nova and strong flicker V2051 Ophiuchi with eclipse mapping techniques to produce the first maps of the flickering brightness distribution in an accretion disc.

Time-series of CCD photometry of V2051 Oph in the B-band were obtained at the Laboratório Nacional de Astrofísica, in southern Brazil, in 1998 and 1999, while the star was in quiescence. V2051 Oph was brighter in 1999 (by $\approx 50\%$). The flickering amplitude is clearly larger in the data of that year, suggesting a dependency of flickering amplitude with brightness level. Therefore, the data of the two years were analyzed separately. We used the ‘ensemble’ technique (Bennie, Hilditch & Horne 1996) to produce lightcurves of the steady (average) and the flickering (residuals) components for each epoch.

The comparison of the steady light lightcurves of 1999 and 1998 indicates that the change in brightness level is mainly due to enhanced emission from the bright spot and gas stream region in 1999, suggesting a long term increase in the mass transfer rate. The flickering curves are distinct from the corresponding steady light lightcurves, showing a narrower eclipse clearly displaced towards later phases with respect to phase zero; they also show a more prominent orbital hump, indicating a significant (anisotropic) contribution from the bright spot.

Maps of the surface brightness of the steady light and of the flickering are obtained by applying eclipse mapping techniques (Baptista & Steiner 1993) to these light curves (Fig. 1). The eclipse maps of the steady light show the bright, compact white dwarf at disc centre plus a faint (and slightly asymmetric in 1998) disc typical of quiescent dwarf novae; the disc is larger and the bright spot emission at the disc rim is stronger in 1999, underscoring the suggestion that the mass transfer rate was higher than in 1998. The flickering maps are noticeably different from the corresponding maps of the steady light. The 1998 flickering map is dominated by emission from the disc side farther away from the secondary star (i.e. the ‘back’ side of the disc) and from the bright spot at disc rim. The flickering distribution changes significantly from 1998 to 1999, probably in response to the overall increase in brightness of the system. The 1999 flickering map shows enhanced emission along the gas stream trajectory as well as a (reduced) contribution from the back side of the disc. A contribution from the inner disc regions (absent in 1998) is also visible.
The changes in the spatial distribution of the flickering sources suggest that the flickering in V2051 Oph is associated to inhomogeneities in the mass transfer from the secondary star. Our interpretation of the flickering maps invokes the ‘magnetic propeller’ model of Horne (1999). In a lower accretion regime (e.g., 1998), the incoming blobs of gas extract energy and angular momentum from the magnetic field of the inner disc regions (or the WD) to be flung out of the binary towards the back side of the disc, producing the observed flickering distribution as they collide with each other and/or with the disc material. When the mass accretion rate increases (e.g., in 1999), the gas plasma blobs have enough specific kinetic energy to start being accreted by losing angular momentum in their interaction with the inner disc (or WD) magnetic field, sweeping around the disc roughly along the ballistic stream trajectory to produce the observed flickering distribution until they are destroyed by the action of the disc viscosity.

References

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