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The flickering of the dwarf nova OY Carinae in quiescence

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Abstract. We observed OY Car with the SOAR Telescope between 2014 February-April while the object was in its quiescent brightness state. Flickering curves were obtained by the 'Single' (high frequency) and 'Ensemble' (mostly low frequency) methods. We applied 3D eclipse mapping tecniques to the steady light and flickering components curves to map the surface brightness/flickering distribution of the accretion disc. The results show that most of the flickering originates in the circularization radius and along the gas stream trajectory (possibly caused by inhomogeneities or post-shock turbulence in the accretion flow), suggesting that matter is being deposited (and remains "frozen") at the circularization radius of a low viscosity accretion disc.

Resumo. Nós observamos OY Car com o Telescópio SOAR entre fevereiro-abril de 2014 quando o objeto estava no seu estado quiescente de brilho. Curvas de *flickering* foram obtidas pelos métodos 'Single' (altas frequências) e 'Ensemble' (dominado pelas baixas frequências). Aplicamos a técnica de mapeamento por eclipse 3D nas curvas de luz estacionária e da componente *flickering* para mapear a distribuição superficial de brilho/*flickering* do disco de acréscimo. Os resultados mostram que a maior parte do *flickering* se origina no raio de circularização e ao longo da trajetória do jorro de matéria (possivelmente causado por inomogeneidade ou turbulência pós-choque no jorro de acréscimo), sugerindo que a matéria está sendo depositada (e permanece "congelada") no raio de circularização de um disco de acréscimo de baixa viscosidade.

Keywords. Stars: dwarf novae – binaries: eclipsing – novae, cataclysmic variables

1. Introduction

OY Carinae is a short period dwarf nova ($P_{orb} \simeq 91$ min) of the SU UMa type. Its light curves show deep eclipses (~ 2.5 mag), which last ~ 9 min, as well as outbursts and superoutbursts on a days-months time scale.

Two models compete for the explanation of the causes of these outbursts. The disc instability model (DIM, Lasota 2001) attributes the outbursts to a thermal-viscous instability in the disc that causes it to cyclically transition between a cold, low viscosity state ($\alpha \sim 0.01$, quiescence) and a hot, high viscosity state ($\alpha \sim 0.1$, outburst). On the other hand, the mass transfer instability model (MTIM, Bath 1972) attributes the outbursts to the response of a disc with constant (and high) viscosity to sudden increases in the mass transfer rate from the secondary.

Flickering is an intrinsic brightness variation at time scales from seconds to tens of minutes seen in light curves of dwarf novae and all objects in which accretion occur (Warner 1995; Baptista & Bortoletto 2004, and their references). In dwarf novae, flickering may originate in (i) the region of the disc-stream impact (possibly caused by instability in the mass transfer or post-shock turbulence) (Warner & Nather 1971; Shu 1976), (ii) the innermost disc regions (possibly generated by unstable accetion onto the white dwarf or post-shock turbulence in the boundary layer)(Elsworth & James 1982; Bruch 1992), and (iii) the accretion disc itself (probably a consequence of magneto-hydrodynamic turbulence or magnetic reconnection events in the atmosphere of the disc) (Geertsema & Achterberg 1992; Kawaguchi et al. 2000; Baptista & Bortoletto 2004).

2. Analysis and results

OY Car was observed with SOI/SOAR in 2014 February-April when it was in the quiescent brightness state. The data cover 23 binary orbits. Individual light curves present $\sim 30\%$ variations in brightness and corresponding changes in the morphology of the orbital hump and eclipse that lead us to separate them into two distinct (high- and low-) brightness states. Flickering curves were obtained by the 'Single' (high frequency, Bruch 2000) and 'Ensemble' (mostly low frequency, Horne & Stiening 1985) methods. We used 3D eclipse mapping techniques to obtain the disc + edge brightness distributions of the steady light and the flickering components (e.g., Saito & Baptista 2016; Baptista et al. 2016). The results are shown in Fig. 1.

The steady light map of the low-state is dominated by contributions from the compact white dwarf and bright spot at disc rim, with very low disc emission. In the high-state map the accretion disc is brighter and larger, and the bright spot is fainter, possibly as a consequence of a larger mass transfer rate. Flickering maps of the low- and high-state are similar, with a central source and a bright spot component plus enhanced emission at the circularization radius, but the intensities are larger in the high-state. There is no clear disc flickering component, suggesting a low viscosity accretion disc (see, e.g., Baptista et al. 2016). The bright spot flickering is of low frequency, whereas the accretion disc has both high and low frequency flickering components.

3. Conclusion

Our study reveals that the flickering amplitude scales with brightness level. The bright spot flickering is of low frequency, whereas in the accretion disc we have flickering of both high and low frequencies. While there is almost no evidence of gas stream emission in the low-state steady light, this component appears clearly in the correspond flickering map, suggesting that the emission of this source is almost entirely in the form of flickering. The bright spot flickering has a relative amplitude of $\sim 20\%$. Most of the flickering originates in the circularization

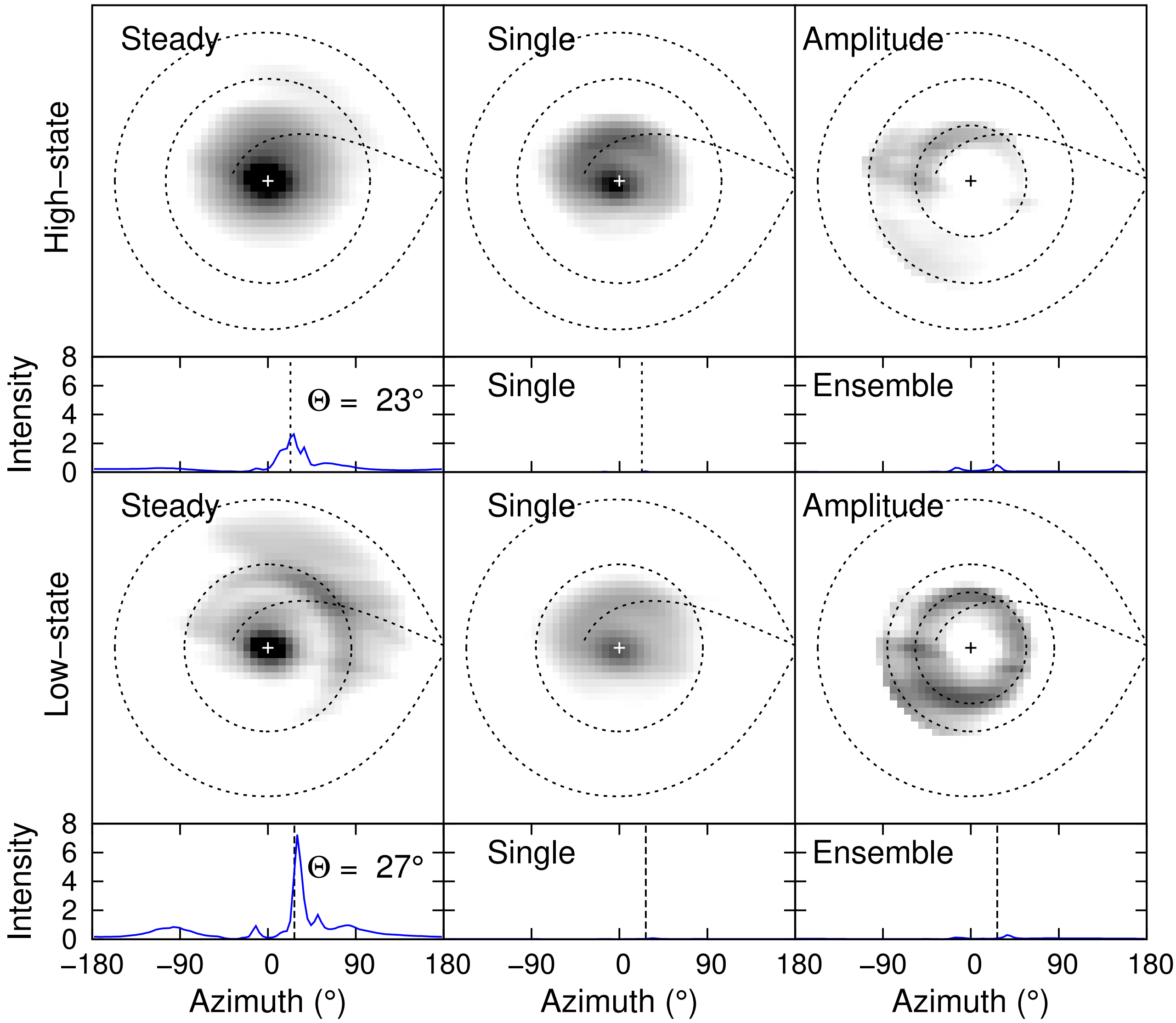

Figure 1. *Left-hand panels:* Steady light eclipse maps of the high- (top) and low-states (buttom) in logarithmic grayscale. Dashed lines shown the Roche lobe, the radius of the accretion disc, and the ballistic gas stream trajectory. Inset panels show the brightness distribution of the disc rim. The dotted line indicates the azimuthal position of the bright spot from the intersection of the ballistic gas stream trajectory with the disc rim. *Center panels:* Single flickering eclipse maps in logarithmic grayscale, and corresponding distribuition of the disc rim. *Right-hand panels:* Relative amplitude of the Single flickering with respect to the steady light in logarithmic grayscale, and Ensemble flickering distribuitions of the disc rim. An additional dashed line depicts the circularization radius.

radius and along the gas stream trajectory (possibly caused by inhomogeneities or post-shock turbulence in the accretion flow), suggesting that matter is being deposited (and remains "frozen") at the circularization radius of a low viscosity accretion disc.

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