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Spatially- and velocity-resolved emission line disk spectra of V2051 Oph along outburst

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Abstract. We report the analysis of time series of optical spectroscopy of the eclipsing dwarf nova V2051 Oph along three consecutive nights covering the maximum, and the decline of its 2002 July outburst. We present spatially- and velocity-resolved disk spectra of the $H\gamma$ emission line along the outburst using eclipse mapping techniques. Emission line profiles are asymmetric and vary with distance from disk center. Presence of P Cygni profile in the spectra suggests mass loss in a highly collimated disk wind (opening angle $\theta \sim 15 \pm 5°$) originating from the inner disk regions ($\sim 0.15\ R_{L_1}$).

Resumo. Relatamos a análise de séries temporais de espectroscopia óptica da novã anã eclipsante V2051 Oph ao longo de três noites consecutivas cobrindo o máximo e o declínio de sua erupção de julho de 2002. Apresentamos espectros do disco na linha de emissão de $H\gamma$ resolvido por velocidade e espacialmentealmente ao longo de uma erupção usando técnica de mapeamento por eclipse. Os perfis de linha de emissão são assimétricos e variam com a distância do centro do disco. A presença de perfil P Cygni nos espectros sugere perda de massa altamente colimado (ângulo de abertura $\theta \sim 15 \pm 5°$) proveniente das regiões interna do disco ($\sim 0.15\ R_{L_1}$).

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

1. Introduction

Dwarf novae (DNs) are close binary stars in which a white dwarf that accretes matter from a solar-type companion. They show repeated outbursts lasting from days to weeks and recurring on timescales from weeks to years, in which their accretion disk brighten by factors 20-100. Outbursts are unpredictable, and observations covering such events are rare and precious.

V2051 Oph is an eclipsing DN with $P_{orb} \simeq 90$ min undergoing sparse outbursts a few days long, possibly in response to sudden changes in mass-transfer from the mass donor star (Baptista et al. 2007). It was observed for four consecutive nights in July 2002 with the optical spectrograph Boller & Chivens coupled to the 1.5 m ESO telescope with spectral range of 3600 - 5950 Å. By fortunate coincidence, these observations coincided with the binary outburst covering the rise to maximum and the subsequent decline back to quiescent state. Due to the good spectral resolution and good temporal resolution, the data allows for the use of the indirect image technique to map the brightness distribution of the accretion disk along the outburst. Here we report the analysis of spectral mapping of the $H\gamma$ emission line of the three last nights of that outburst.

2. Analysis

Light curves of $H\gamma$ were sampled from -2000 km s^{-1} to +2000 km s^{-1} using velocity bin of 500 km s^{-1} centered at the rest wavelength, $v = 0$ km s^{-1}. Maximum-entropy eclipse-mapping techniques (Horne 1985; Baptista 2001) were used to solve for a map of the disk brightness distribution at each velocity bin. We adopted the binary parameters of Baptista et al. (1998), $q = 0.19$ and $i = 83.3°$, and a square eclipse map with 51×51 pixels centred at the white dwarf position.

Each of the eclipse maps yields the information about the emitting region on a specific velocity bin. By combining 8 velocity maps we are able to isolate the shape of $H\gamma$ line emission line at any desired position on the dis. In order to separate the disk spectra at different distances from the disk center, we sliced the eclipse map in a set of five concentric annular sections of width $\Delta R = 0.1\, R_{L_1}$ and computed the average intensity inside each annulus. The statistical uncertainties affecting the average intensities are estimated with Monte Carlo simulations.

Figure 1 shows the resulting $H\gamma$ line profiles for outburst maximum (top panel), early decline (middle panel) and late decline (bottom panel). $H\gamma$ appears in emission at all disk radii, with a typical broad, double-peaked disk profile in the outer disk regions. The line profile is asymmetric and varies with distance from disk center; the red peak is stronger at smaller radii and the blue peak becomes progressively stronger with increasing radius. The innermost disk regions show a P Cygni profile indicating origin in an outflowing gas, probably a disc wind (Cordova & Mason 1985). From the binary parameters we estimate the disk wind opening angle θ using $\theta = i - \arccos(V_{escape}/V_{observed})$, where $V_{escape} = \sqrt{G\, M_1\, R^{-1}}$ and $V_{observed}$ is the observed velocity of the absorption component. We find a highly collimated disk wind (opening angle of $\theta \sim 15 \pm 5°$) originating from the inner disk regions ($\sim 0.15\ R_{L_1}$).

3. Conclusion

Our preliminary data analysis show that the $H\gamma$ emission line profiles are asymmetric and vary with distance from disk center. Presence of P Cygni profile in the spectra suggests mass loss in a highly collimated disk wind. Spectral mapping is a powerful probe of the physical and dynamical conditions in an outbursting accretion disk. By extending the analysis to the full wavelength and time coverage of our data we will be able to test the connection between the suggested disk wind outflow and the onset of the outburst, and we will search for signals of spiral arms in the outbursting accretion disk (as suggested by the asymmetric double-peaked line profile).

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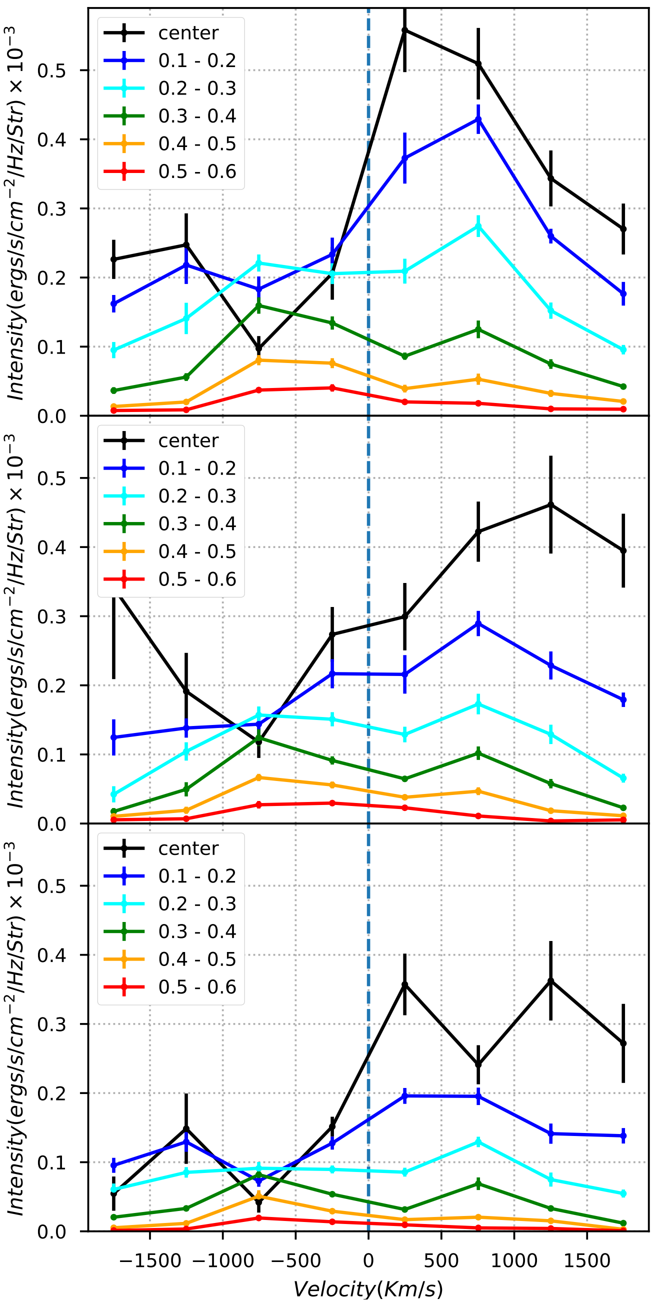

FIGURE 1. Disc spectrum as function of radius plotted in velocity centered in $H\gamma$, marked by vertical dashed line. Top panel corresponds to outburst maximum, second and third are decline to quiescence. Colors of each curve are indicated in the graph where each value correspond to an annulus disc radius as function of L_1. From the center of the disc increasing in steps of $0.1L_1$ up to $0.6L_1$, outer parts of the accretion disc.

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