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FLUCTUATIONS IN THE FLOW AND DEVELOPMENT OF FLARE-UPS IN COMPACT BINARY STARS

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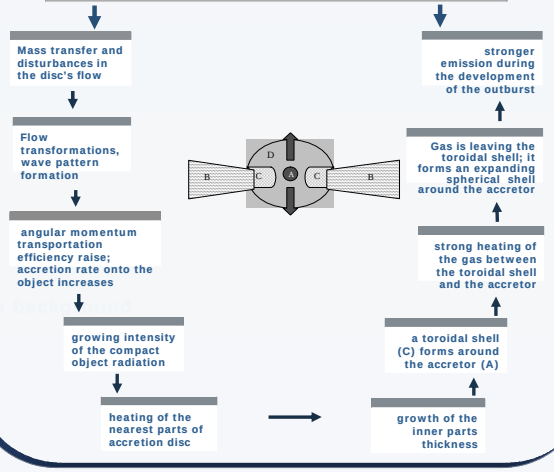
INTRODUCTION AND THE PROBLEM BACKGROUND

We present several methods for investigation of flare-up events in accreting compact binaries. The theoretical modeling explains the physical properties of flow unstable processes. It shows gas-dynamical mechanisms that are considered to be the most operative for the occurrence of flares in the binary star configuration. The changes in mass transfer rate and disturbances of the disc structure can also trigger bursts activity. This results in low amplitude oscillations manifesting as sporadic variations on the light curve. Brush (1992) has proposed four possible mechanisms responsible for the observed variations in brightness: unstable mass transfer from the L1 point and interaction with the disc edge; dissipation of magnetic loops; turbulences in the accretion disc and unstable mass accretion onto the white dwarf. The turbulent mechanism of angular momentum transportation is also suggested by Dobrotka in (Dobrotka et al. 2010). Bisikalo et al. 2001 have proposed a model that explains the variations of uneclipsed parts of light curves correlate with the presence of spiral shocks. Their observations correspond to the with of variations to the theoretical one. In Boneva et. al (2009) and Kononov et al. (2008) we have showed the relation between the flow's elements dynamics and the active state of SS Cyg.
In the current survey, we investigate the relationship between the disc's flow fluctuations and the burst activity, which has an effect on the light curve shape's behavior. We study the mechanisms that cause the accretion rate to sufficiently increased and then to realize the transition from a quiescent to an active state. The results reveal the accumulation of mass that could be transferred to the surface of the white dwarf from the secondary star through an accretion disc. It is also observed the structure transformations, accompanied with the flow patterns formation could trigger outbursts. We analyze the observational results of quasi-periodic variability in the luminosity of white dwarf binary stars systems. We discuss the possibility of applying the polarization modeling into the study of brighten-up events in dwarf nova stars.

SUGGESTED METHODS

- Gas-dynamical numerical calculations: Finite-difference scheme – high order; Roe solver; Box-framed scheme.
- Doppler Tomography: To construct the true cart of image of the obtained data; to derive the radiation intensity distribution in the system's velocity space, making it possible to determine the parameters of the main flow elements in which energy is released.
- Polarimetry methods.

We use as a base the model of outburst in SS Cyg, presented in (Kononov et al. 2008 and (Boneva et al. 2009) and we propose it here:



- free boundary conditions at the outer disc edge + constant density: $\rho_{out} = 10^{-7}\rho_{L1}$, where ρ_{L1} is the density of the inner Lagrangian point ~ L_1.
- non-constant density in the inner parts;
- boundary conditions of Dirichlet and Cauchy Type: defined the radius of vortex and the boundary area of equations activity;
- baroclinicity conditions of (Klahr & Bodenhiemer 2003, Klahr 2004, Petersen 2007);

POINTS

- When material reaches the compact object surface through the disc, it must pass through a violent transition region.
- We establish a part of disc's configuration around the primary (white dwarf) star after the mass transfer being started.
- when investigating close components, it is necessary to include physical essence of the flow dynamics response to the interaction processes.

Indications of flow's fluctuations and flare-ups

DENSITY FLUCTUATIONS

The disturbed flow's conditions can provoke periodic or quasi-periodic oscillations, giving rise to the light curve variations. In this way, the amplitude of light curve variations should be approximately correspond to the density contrast.

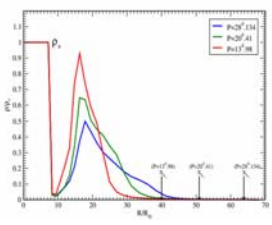


Figure 1. Density distribution along the line connecting the centers of binary components for three runs with different orbital periods. The density is normalized to the surface density of B-star. Positions of L1 for each model are showed by arrows. (Kaygorodov, Bisikalo, Kononov, Boneva, 2013)

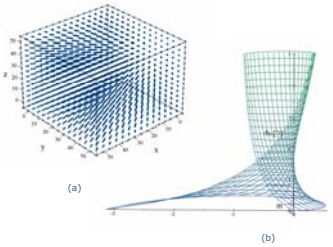
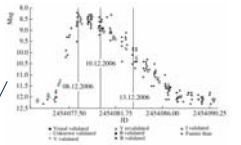
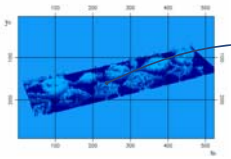


Figure 2. (a) Gradient of the density distribution in the field of calculation. It is seen the higher density areas, in the meaning of values heaping, modeled in the 3D box – framed scheme. (b) Increasing values of the density fluctuations in the disturbed mass transfer area

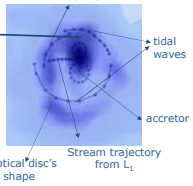
WAVE - PATTERNS FORMATION

According to the model above, when this kind of wave patterns leave the disc zone, they could crumble and merge into the matter of the curcumdisc hallo, influenced by the conditions of low density there. It follows from the results of that the density of outer regions of the accretion disc drops substantially during an outburst.



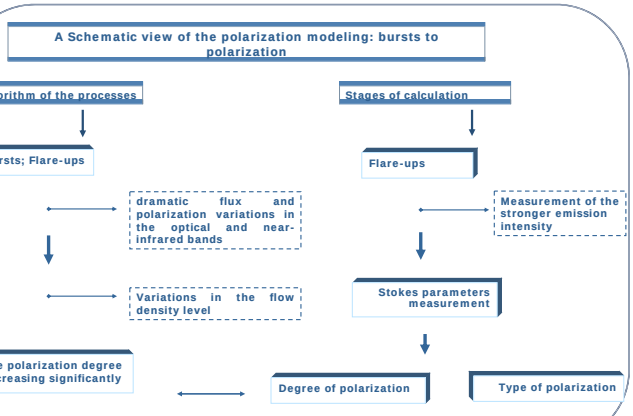


Vortical-like wave patterns may propagate throughout the disc, along the outer sides (Figure3).



The flow structure during the outburst. A result from the Doppler tomogram with superposed flow elements inferred from the numerical simulations (Figure 4).

Light curves of SS Cyg based on AAVSO light curve data generator (figure 5). The vertical lines indicate the dates of our observing nights.



CONCLUSION

In this survey, we present our modeling on the disc's flow morphology and its effect over the binaries' brightness variability. The model is developed on the base of increasing density and local areas with growing matter saturation. We have analyzed the flow structures during the outbursts and we indicate flow's fluctuations have been growing up in the mass transfer area. Our recent study also points to the long-lived wave patterns formation, which come rising by the tidal interaction in close binaries.
The casual low-magnitude variations on the light curve can also be a consequence of the presence of the vortical-like patterns in the disc structure.

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