*SF2A 2006*
*D. Barret, F. Casoli, T. Contini, G. Lagache, A. Lecavelier, and L. Pagani (eds)*

# HYDRODYNAMIC SIMULATIONS OF IRRADIATED SECONDARY STARS IN DWARF NOVAE

M. Viallet and J. M. Hameury[1]

**Abstract.** We investigate the possibility of a mass transfer enhancement during outburst in dwarf novae. We present here the first two-dimensional hydrodynamic simulations of the surface flows in the secondary, driven by the strong inhomogenous heating of the atmosphere during an outburst. We also discuss the possibility that the direct heating of the $L_1$ point by the disc rim contributes to the mass transfer enhancement

## 1 Introduction

It is believed that outbursts in dwarf-novae are due to a thermal-viscous instability of their accretion disc (see Lasota 2001 for a review). In the basic version of this model, the mass transfer rate from the secondary is assumed to be constant. There are however observational evidences for enhanced mass transfer during outbursts (see Smak 1995, 2004b) possibly due to the strong illumination of the secondary. There is however a controversy on both the interpretation of observations and the effects of irradiation of the secondary (see Osaki 2003, 2005 and Smak 2004a, 2004c).

Indeed, as the $L_1$ point is shadowed by the accretion disc, no direct heating is possible. Furthermore, the Coriolis force strongly constraint the dynamic of the irradiated atmosphere, preventing any direct meridional transport of heat from the irradiated region toward $L_1$ (see Osaki 2003). The complexity of the Roche geometry could however allow for a more complex transport mechanism, making e.g. profit of the rapid change in the geometry of the star away from the $L_1$ meridian.

## 2 Preliminary results

We present here the first investigation of the dynamical effect of the irradiation on the secondary atmosphere. As the scale height of the stellar atmosphere is much lower than the stellar radius, we consider the atmosphere as being infinitely slim. We use a TVD-McCormack scheme (see Yee 1987) to solve the 2D Euler equations describing the surface flow in the secondary. As the Coriolis force is the most important physical ingredient, we consider for simplicity a spherical star with an explicitly space dependant Coriolis force that mimics the Roche geometry. We consider here the case of a short period system such as OY Car.

Fig. 1 shows the temperature distribution at the surface of the secondary : the left-hand side corresponds to the initial condition, where the equatorial regions are shaded by the disc, and the right-hand side shows the temperature distribution after 15 orbital periods. As one can see, the hot and cold region are mixed and the process is clearly 2D. The $L_1$ point could be heated this way and as a result the mass transfer rate will be enhanced. Investigations on the mixing mechanism and implications for the outburst behavior are currently under way.

We also consider the possibility that the disc rim himself could heat the $L_1$ point. For systems of the SU UMa subclass, the secondary surface is cold enough that heating by the disc rim in outburst can be significant.

We have implemented this effect in the disc evolution code from Hameury et al. 1998. The mass transfer rate, depending on the temperature of $L_1$, is calculated as in Smak (2004a).

Fig. 2 shows the enhancement of the mass transfer in case of a secondary surface temperature of 2300 K. $\dot{M}$ can by increased by up to 20, with an effective mean value of $\sim 5$. The dependance of the surface temperature, the effect on the outbursts light-curves and comparison with the non-heated case are currently under investigation.

[1] Observatoire de Strasbourg, 11 rue de l'Université, 67000 Strasbourg

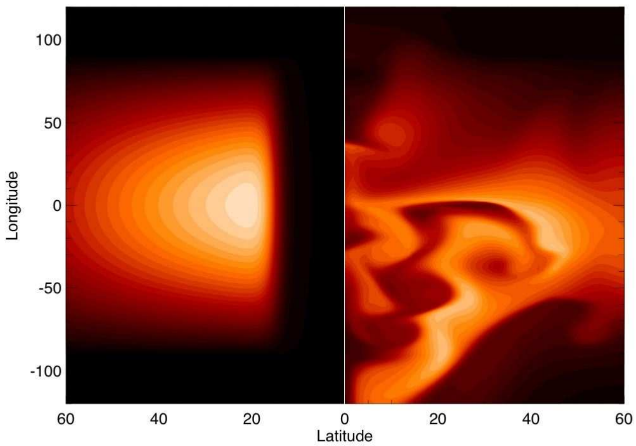


**Figure 1.** Initial temperature distribution (left) and after 15 orbital periods (right).

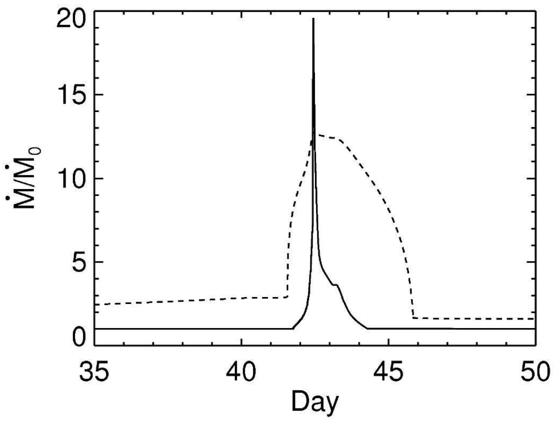


**Figure 2.** Mass transfert enhancement during an outburst, the outburst light curve is overplotted for comparison.

## 3 Conclusions

Our first results shows that the basic assumption of a constant mass transfer rate is likely to be incorrect, as suggested by observations. It is however not yet clear how both the irradiation of the secondary and the direct heating by the disc rim affect predictions of the disc instability model. It should be interesting to check how they could resolve some of the deficiencies of the actual version of the model.

## References


Hameury, J.M. et al. 1998, MNRAS 298, 1048

Lasota, J.P. 2001, New Astronomy Reviews 45, 449

Osaki, Y. & Meyer, F. 2003, A&A 401, 325

Osaki, Y. & Meyer, F. 2004, A&A 428, 17

Smak, J. 1995, Acta Astronomica 45, 355

Smak, J. 2004, Acta Astronomica 54, 181

Smak, J. 2004, Acta Astronomica 54, 221

Smak, J. 2004, Acta Astronomica 54, 429

Yee, H.C. 1987, Nasa Technical Memorandum 89464