The Influence of the Rotation Velocity Gradient on the Line Profiles of Accretion Discs of Cataclysmic Variables

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Introduction

The Doppler effect has an important consequence for the spectral line formation. Due to the frequency shift, the escape probability of photons is higher. Here, we try to find answers to these questions: How large is this effect in the discs of cataclysmic variables (CVs)? How accurate is the common approximation, where the velocity field is included in the radiative transfer equation, is indicated by a red line. The blue line denotes the case, where the gradient of the velocity field is included in the radiative transfer equation, is indicated by a red line. The blue line denotes the case, where the velocity field is taken into account only in the flux calculation.

Model description

The detailed description of our model can be found in Korčáková et al. (2011). Here, we only mention the main properties of the disc. The vertical hydrostatic structure together with opacity and emissivity coefficients are calculated using the AcDc code (Nagel et al. 2004). The output from this code serves as an input for the radiative transfer code (Korčáková & Kubát 2005). This reduces time and memory requirements and allows to solve the radiative transfer problem through all the disc structure with inclusion of the velocity gradient.

2.5D radiative transfer model

The technique is very similar to the method described in Korčáková & Kubát (2005). It assumes axial symmetry. This reduces time and memory requirements and allows to solve the radiative transfer problem through all the disc structure with inclusion of the velocity gradient.

Results

Figs. 1 and 3 show the distribution of source function and opacity in the disc. The resulting line profiles under different inclination angles are plotted in Fig. 2. The model is calculated for SS Cyg in Hα and Hγ lines and Hel 4923Å line for a disc of an AM CVn system. The solution, where the gradient of the velocity field is included in the radiative transfer equation, is indicated by a red line. The blue line denotes the case, where the velocity field is taken into account only in the flux calculation.

Conclusion

The results (see Fig. 2) prove, that the Doppler shift in the media itself has a negligible effect on the line formation. Even for high inclinations (the third graph in the individual figures is a view just above the edge of the disc) the difference is very small.

A huge difference is obtained at the edge-on view. The specific intensity integration along this boundary includes only the lowest value of the rotation velocity. To reflect all the velocity distribution in this case, the velocity must be included in the radiative transfer. Even if the outgoing radiation in this region is about an order of magnitude weaker than at the face-on view, it can have an important influence for the study of self-shielding discs (e.g. some UX UMa or SW Sex systems).

Due to the integration of the radiation field at the disc boundary and sufficiently opaque media our calculations prove, that the rotation velocity field has a negligible influence in the line formation in discs of CVs. The classical approximation of the disc as a set of the concentric rings is valid with high accuracy.

References

Werner, K., Dreizler, S. & et al. 2003, ASPC, 288, 31