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3D non-LTE radiative transfer: a new code and its application to γ^2 Velorum

Doris Folini and Rolf Walder

Institut of Astronomy, ETH Zürich, Switzerland

Abstract. A new approach to 3D optically thick non-LTE radiative transfer for moving media is presented. As a first application, we look at the ionization state of the colliding winds interaction zone between two stars.

1. Introduction

Numerical simulations show that the distribution of circumstellar matter in close massive binary systems is asymmetric. The density of the colliding winds interaction zone is found to be much higher than that of the undisturbed stellar winds. We have developed a multidimensional, optically thick non-LTE radiative transfer code for moving media (Section 2) to cope with such situations and have applied it to a first toy example (Section 3).

2. The code

For the continuum, the radiative transfer equation is solved using a new kind of approach, namely a generalized mean intensity approach. This approach leads to an equation of the form $AJ = F$. Here A is a matrix describing the transport, absorption, and scattering. J is the generalized mean intensity. F essentially stands for emission. Advantages of this approach are the near independence of the convergence properties on the grid spacing, the comparatively small memory requirements, and that it is fast. A full documentation of this approach can be found in Folini (1998). A concise outline is given in Folini & Walder (1999).

As we cannot afford to solve the transfer equation also for spectral lines we treat those in the rate equation part via Sobolev theory, extended to 3D (see Folini 1998). The electron temperature is assumed to be known.

3. A toy model of γ^2 Velorum

As a first application of our code we look at the colliding winds interaction zone between two massive stars. Various authors (see *e.g.*, Marchenko *et al.* 1997) have already shown that the cold part of such an interaction zone can influence the emitted spectrum. The model we use is a toy model of γ^2 Vel. It has to be stressed that this model is still far from the real system γ^2 Vel.

First we performed a 3D isothermal hydrodynamical simulation of our model (for parameters see Walder, Folini & Motamen, these Proceedings). Then

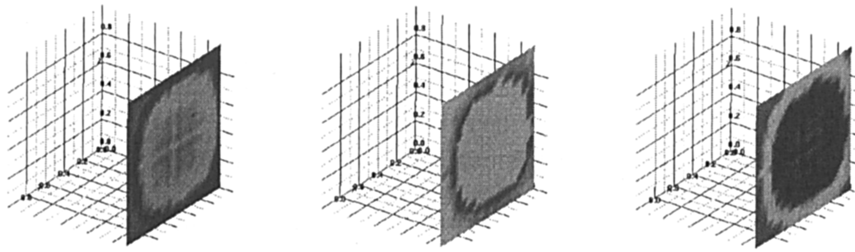

Figure 1. Ratio of N IV, N V, and N VI (from *left* to *right*) to the total amount of nitrogen. White (black) indicates 0 (1). Shown is a slice normal to the orbital plane and close to the O-type star. The nearly circular structure corresponds to the high density interaction zone.

we applied the radiative transfer code to the output of this simulation. The stellar fluxes have been taken from Schmutz & De Marco (1998).

As a first result, we find that the code is generally suited for attacking such problems, although a few improvements have to be made. The astrophysical results are still very preliminary. The present model predicts that the degree of ionization is considerably reduced within the cold, dense interaction zone located close to the O-type star. The radiation field is, however, not too much weakend by the interaction zone: the ionization state on either side is roughly equal, within about a factor of two (see Figure 1). We also find that optically thick effects become indeed important in the interation zone[1].

4. Conclusions

Our results show that 3D optically thick non-LTE radiative transfer gets within the reach of present day computers and numerical methods. The existence of a rather lowly ionized high density emission region close to the O-type star is predicted. Optically thick approaches may reveal further secrets of massive binaries.

References

Folini, D. 1998, PhD thesis, ETH No. 12606

Folini, D., Walder, R. 1999, Proc. 7th Intern. Conf. on Hyperbolic Problems (Basel: Birkhäuser), in press

Marchenko, S.V., Moffat, A.F.J., Eenens, P.R.J., Cardona, O., Echevarria, J., Hervieux, Y. 1997, ApJ 485, 826

Schmutz, W., De Marco, O. 1998, private communication

[1] For papers and additional pictures: http://www.astro.phys.ethz.ch/staff/folini/research.html

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