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Multicomponent stellar wind of hot stars

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Abstract. We developed a time-dependent multicomponent hydrodynamics code for the simulation of stellar winds from hot stars and applied it to sample stars.

1. Simulation of multicomponent stellar wind

One of the major aproximations of CAK theory (Castor, Abbott, & Klein 1975) is the one component fluid aproximation. But in fact, the radiative line force acts on ions only, which share their momenta through Coulomb collisions with protons that make up the bulk part of the plasma. The dynamical effect of Coulomb collisions on the plasma is well described by dynamical friction, as was derived by Spitzer (1956).

We numerically solve the time-dependent hydrodynamic equations for a multicomponent, radiatively driven flow (Pauldrach et al. 1986). As a first test, we applied our code for cases where a well-coupled wind is expected. More specifically, we perform tests for stars with basic parameters corresponding to κ Cas and τ Sco.

We summarize our model parameters in the Table 1. For each star we compare results of the two-component simulation with the one-component simulation (see Fig. 1).

Table 1. Global stellar parameters for our models. Stellar mass $M_\star$, effective temperature $T_{\rm eff}$, and stellar radius $R_\star$ are after Wilson & Dopita (1985). The CAK constants k, α, and δ are taken from Abbott (1982). q_i/q_p is the charge ratio.

Star	$M_\star$ $[M_\odot]$	$T_{\rm eff}$ [K]	$R_\star$ $[R_\odot]$	α	k	δ	q_i/q_p
κ Cas	29.0	21600	35.4	0.5	0.287	0.09	3.0
τ Sco	20.0	32000	6.7	0.609	0.156	0.057	3.0

For a well-coupled stellar wind, the multicomponent velocity law develops quickly from (almost) arbitrary initial conditions to a solution that is close to

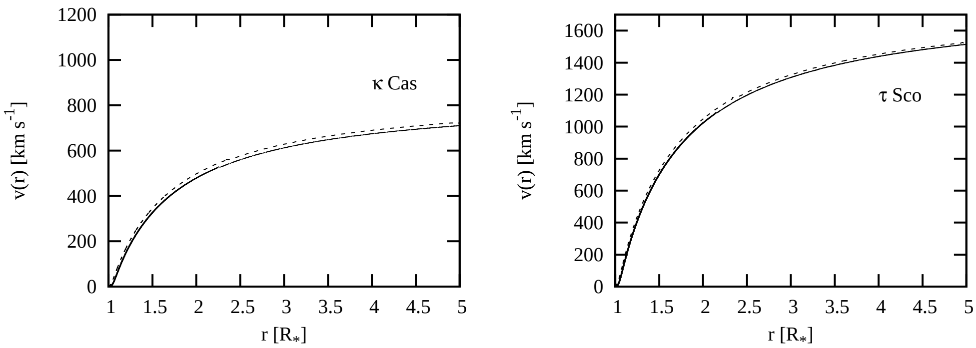

Figure 1. Velocity profile for the multicomponent (solid line) and one-component (dashed line) model for κ Cas and τ Sco.

the (modified) CAK one-component solution. The agreement in terminal speeds is very good.

For a low density wind, where dynamical friction is not so effective and decoupling may occur, a numerical problem with a strong decoupling instability (Owocki & Puls 2002) appears.

2. Conclusion

We are able to simulate a multicomponent stellar wind from stars having a well-coupled wind. We find numerical problems in the simulations of low density radiatively-driven stellar winds, which indicate the possibility of wind decoupling. This mechanism may offer an explanation of certain peculiarities in the circumstellar environment of some B stars.

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