Two-component stellar wind in hot stars

Jiří Krtička[1,2], Jiří Kubát[2]

[1] *Katedra teoretické fyziky a astrofyziky PřF MU, Kotlářská 2, CZ-61137 Brno, Czech Republic*
[2] *Astronomický ústav AV ČR, CZ-25165 Ondřejov, Czech Republic*

Abstract. We present results of the solution of hydrodynamic equations of a two-component radiatively driven stellar wind with inclusion of the frictional force. We found that friction does not lead to significant separation of the components. However, the outflow velocity is substantially decreased with respect to the one-component model.

1. Introduction

Recent results of modeling of hot star winds indicate the possibility of a multicomponent nature of a low mass loss rate wind. Springmann & Pauldrach (1992) showed that friction between absorbing ions and passive plasma leads to the heating of plasma and to the decoupling of radiatively accelerated ions. Babel (1995) computed hydrodynamical model of a multicomponent wind of main sequence A star. Both papers support the idea that low-density radiatively driven winds may decouple at some point. We aim at studying this effect for the case of B stars.

2. Calculation of the model of a two component wind

We assume that the wind consists of two components. The first one is the passive plasma consisting of hydrogen ions, the second one is a mixture of metal ions that are able to absorb enough radiation to be accelerated. In addition, we assume spherical symmetry and we set the wind temperature equal to the effective temperature of the star. We solve the hydrodynamic equations (equations of continuity and motion) using a slightly modified Henyey method (Henyey et al. 1964). Parameters of each main-sequence star for which we computed a model

Table 1. Parameters of model stars – T_{eff}, $\mathfrak{M}_\star$, $R_\star$ after Harmanec (1988), wind parameters k, α, δ from Abbott (1982).

Stellar	Stellar parameters			Wind parameters			Average ion	
type	$\mathfrak{M}[\mathfrak{M}_\odot]$	$R_*[R_\odot]$	$T_{\mathrm{eff}}[\mathrm{K}]$	k	α	δ	$q_\mathrm{i}/q_\mathrm{p}$	A_i
O6	31.65	9.85	41 700	0.174	0.606	0.12	3.0	12.0
B6	3.80	2.81	14 100	0.275	0.517	0.106	2.0	12.0

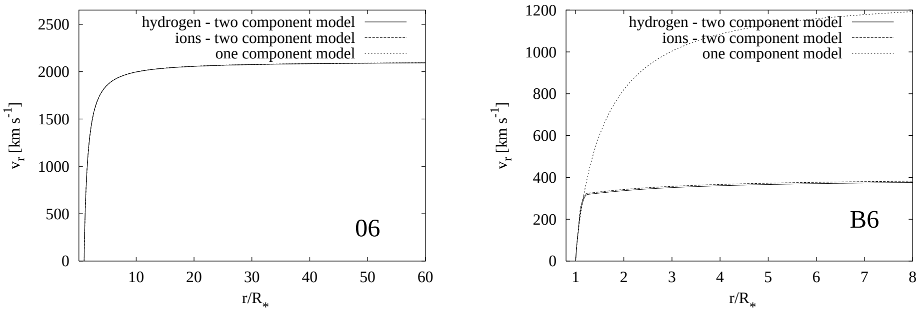

Figure 1. The run of the ion and hydrogen velocities in the wind for the cases of O6 and B6 stars. For the O6 star all curves are identical.

are given in the Table 1. Our assumptions extremely simplify the problem, so the results should be considered as a qualitative description of the situation.

3. Results and conclusions

Our results are shown in Fig. 1. We plotted the run of the ion and hydrogen (passive plasma) velocities across the wind. The weak effect of decoupling can be seen in the right panel of Fig.1 displaying the wind velocity for a B6 star. However, much more striking effect is the decrease of wind velocities with respect to the one-component solution. The reason for the abrupt decrease of the velocity gradient is subtle and is hidden in the nonlinear nature of equations of motion. It results in slight lowering the velocity gradient. Lower velocity gradient means also *lower radiative force*, consequently lower acceleration and even lower velocity gradient. The latter process finally almost stops the acceleration of the wind as can be seen especially for later B stars.

Our new simple hydrodynamic calculations show the effect of slowing down the wind of cool B stars by friction between radiatively accelerated ions and passive plasma. This effect is stronger for later B stars and weaker for earlier B stars. It is completely missing for O stars. Finally, we would like to mention the measurements of v_∞ for a large sample of stars by Lamers et al. (1995). They found a sudden drop of v_∞ near $T_{\rm eff} = 21000\,{\rm K}$ with respect to earlier stars. We found the same trend in our simple calculations.

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