

# Delta-slow solution to explain B supergiant stars' winds

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**Abstract.** A new radiation-driven wind solution called  $\delta$ -slow was found by Curé *et al.* (2011) and it predicts a mass-loss rate and terminal velocity slower than the fast solution (m-CAK, Pauldrach *et al.* 1986). In this work, we present our first synthetic spectra based on the  $\delta$ -slow solution for the wind of B supergiant (BSG) stars. We use the output of our hydrodynamical code HYDWIND as input in the radiative transport code FASTWIND (Puls *et al.* 2005). In order to obtain stellar and wind parameters, we try to reproduce the observed H $\alpha$ , H $\beta$ , H $\gamma$ , H $\delta$ , HeI 4471, HeI 6678 and HeII 4686 lines. The synthetic profiles obtained with the new hydrodynamical solutions are in good agreement with the observations and could give us clues about the parameters involved in the radiation force.

**Keywords.** stars: mass loss, stars: winds, outflows

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## 1. Introduction

For O supergiant stars (OSGs) and BSGs, the classical theory of radiation-driven winds predicts that their winds' velocity fields can be fitted by a  $\beta$ -law, with a typical value of  $\beta = 0.8 - 1$ . This describes very well the OSGs winds, but for BSGs, observations show values of  $\beta > 1$ , indicating a slower outflowing regime at the base of the wind. To explain this behaviour we present here a preliminary analysis, via a line fitting procedure, of the wind of 3 BSGs (HD 52 382, HD 86 440 and HD 91 619) using this new  $\delta$ -slow solution. To fit the H and He line profiles we used the FASTWIND code, but the input file of the models were done with the code HYDWIND, developed by Curé (2004), which predicts slower and denser winds than the m-CAK theory.

## 2. Results

The parameters obtained from the line fitting for the observed stars are tabulated in Table 1, and the plots are shown in Figure 1.

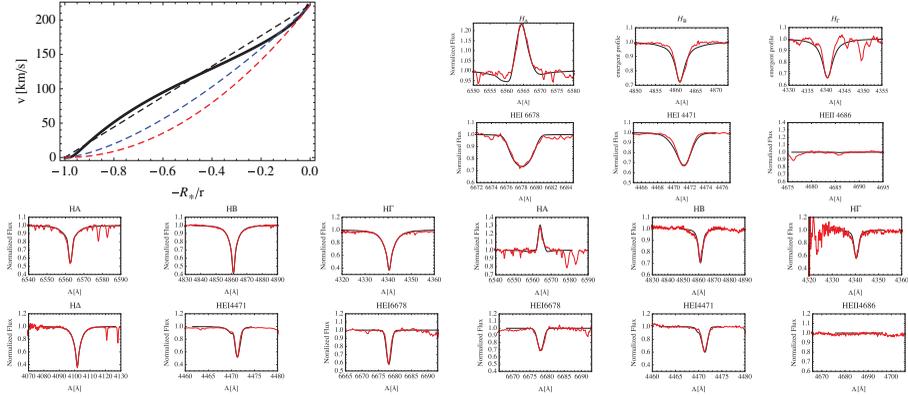
- The  $\delta$ -slow solution fits very well the observations, however for HD 91 619 we need values of  $T_{\text{eff}}$  and  $\log g$  higher than the expected for its spectral type (B7).
- For HD 86 440 and HD 91 619 we obtain a good fit with a  $\delta$ -slow solution using values of  $\delta > 0.4$ .

## 3. Discussion and conclusions

- The  $\delta$ -slow solution seems to describe the wind structure of the BSGs with  $\beta > 1$  at the base of the wind, then it behaves like a  $\beta = 0.7$  for an intermediate region

**Table 1.** Stellar, line force and wind parameters

STAR	$T_{\text{eff}}$	$\log g$	$v_{\text{rot}}$	$R_{\star}$	$\alpha$	$\delta$	$k$	$\dot{M}$	$v_{\infty}$	$v_{\text{micro}}$
HD	K	dex	$\text{km s}^{-1}$	$R_{\odot}$				$10^{-6} M_{\odot} \text{yr}^{-1}$	$\text{km s}^{-1}$	$\text{km s}^{-1}$
52 382	19 000	2.5	100	52	0.52	0.39	0.21	0.47	290	5
86 440	15 000	2.55	60	62	0.52	0.43	0.32	0.15	376	10
91 619	19 000	2.3	40	71	0.52	0.44	0.142	0.5	222	25



**Figure 1.** The upper left graphic shows the velocity field of HD 91 619. Black solid line is obtained with  $\delta$ -slow solution. Black, blue and red dashed lines correspond to  $\beta$ -law with  $\beta = 1, 1.5$  and 2, respectively. The other panels are the fittings to H and He lines for HD 52 382 (upper right), HD 86 440 (bottom left) and HD 91 619 (bottom right).

( $1.1 < r/R_{\star} \lesssim 3.0$ ), but finally, in the outer part of the wind, it approaches again to  $\beta > 1$  (see Figure 1). The  $\delta$ -slow solution reproduces well the observed line profiles.

- HD 52 382 is a variable star with no cyclical behaviour (see Morel *et al.* 2004) and this could be the cause of the differences in the stellar and wind parameters found in the literature, for example,  $v_{\infty} = 900 \text{ km s}^{-1}$  (Howarth *et al.* 1997) and  $\dot{M} = 0.33 \times 10^{-6} M_{\odot} \text{ yr}^{-1}$  (Morel *et al.* 2004).

- For HD 86 440 our results of the  $T_{\text{eff}}$  and  $\log g$  are in agreement with the same values obtained by Fraser *et al.* (2010).

- For HD 91 619 we have the same “difficulties” as Markova *et al.* (2008): if we use lower  $T_{\text{eff}}$  and lower  $\log g$  the absorption component of the synthetic profiles is very intense and does not fit the observed one.

- To reproduce some observations we may need  $\delta$  values  $> 0.4$ . These values are greater than  $1/3$  which is the value expected for a pure H medium (Puls *et al.* 2000).

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