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HYDROGEN AND HELIUM IONIZATION IN THE AXISYMMETRIC ENVELOPES OF B[E] SUPERGIANTS

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Aims: Model atmospheres of B[e] supergiants (sgB[e]) were calculated to test our newly developed 2D stellar atmosphere code (Astaroth). This code will be used to study normal Be and sgB[e] stars, binaries with colliding winds, LBVs, and type-II SNe. For simplicity, we included only H, He, and C in the models presented here.

How the code works: The short-characteristic method is used to treat the continuum transfer while bound-bound transitions are treated by the Sobolev approximation. The simultaneous solution of the transfer equation, the equations of statistical equilibrium, and energy conservation is achieved by preconditioning and linearization (see Georgiev et al. 2006 and Zsargó et al. 2006 for more details).

Models: The spectra of sgB[e] stars show strong evidence for a dense equatorial disk and a more normal polar wind (e.g. Zickgraf et al. 1986). This dual nature is believed to be related to their fast rotation. Recent theoretical calculations of pure H and He atmospheres have demonstrated that neutral H and He can not only survive near the stellar surface, but also can be the dominant form of these species (Kraus & Lamers 2003; Kraus 2006). However, these calculations necessarily involved simplifications, such as simplified radiative transfer and the neglect of ionization from excited states. Our simulations relax many of these approximations and provide a more realistic and self-consistent picture of sgB[e] envelopes. Following Kraus & Lamers (2003) we introduced the 2-component wind by

$$V_r = V_{\infty,\mathrm{pole}} \cdot 10^{-2\sin^{10}\theta} \cdot \left(1 - \frac{R_*}{R}\right)^{\beta_{\mathrm{CAK}}} \quad (1)$$

$$V_\theta = V_\phi = 0 \quad (2)$$

$$\frac{dM_{\mathrm{loss}}}{\sin\theta d\theta} = \left(\frac{dM_{\mathrm{loss}}}{\sin\theta d\theta}\right)_{\mathrm{polar}} 10^{\sin^{10}\theta} \quad (3)$$

where R, θ, and ϕ are the usual polar coordinates.

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TABLE 1

MODEL ATMOSPHERES

	A	B	C
$R_*/R_\odot$		82	
$M_*/M_\odot$		30	
V_∞ (θ= 0°)		2000 km s^{-1}	
V_∞ (θ= 90°)		20 km s^{-1}	
β_{CAK}		0.8	
N(H)/N$_{\mathrm{tot}}$		0.9	
N(He)/N$_{\mathrm{tot}}$		0.1	
N(C) /N$_{\mathrm{tot}}$		9.8E–4	
M$_{\mathrm{loss}}$ (10^{-6} $M_\odot$yr^{-1})	4.0	4.0	40.
T$_{\mathrm{eff}}$ (K)	22500	18000	22500

Several model atmospheres have been calculated with stellar parameters that are similar to those of the prototypical sgB[e] star R 126 in the LMC. These parameters are listed in Table 1.

Results: Our models support the finding that significant amounts of neutral H and He can exist near the stellar surface in the equatorial plane. We find, however, that hydrogen is much more ionized than predicted by earlier calculations, at least in the parameter range so far explored by us. This is the result of ionization from the excited states of H I. We will continue mapping the parameter space allowed for sgB[e]s in follow up studies. Furthermore, we will introduce gravity darkening on the stellar surface and include Fe in our atomic model. The combined effects of line-blanketing by Fe and gravity darkening may significantly affect the ionization structure in the envelope.

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