Stellar Rotation
Proceedings IAU Symposium No. 215, © *2003 IAU*
André Maeder & Philippe Eenens, eds.

Ionization Structure in Equatorial Winds of B[e] Supergiants

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Abstract. The non-spherically symmetric winds of B[e] supergiants are investigated. An empirical density distribution is chosen that accounts for the density concentrations and ratios derived from observations, and our model winds are assumed to contain only H and He. We calculate the Strömgren radii and the more accurate ionization fractions for H and He and find that in equatorial direction the winds of B[e] supergiants can become neutral very near the stellar surface. A neutral disk therefore exists around these stars in which molecules and dust can form which are shielded from the photodissociating stellar radiation field.

1. Introduction

B[e] supergiants are massive and luminous post-main sequence stars with strong non-spherically symmetric winds induced probably due to the rapid rotation of the stars. Observations of dust and molecules indicate that there must exist some neutral regions near these stars that are shielded from the ionizing and dissociating stellar radiation field. Our goal is to show that in the equatorial regions where the slow, high density wind forms a disk-like structure, hydrogen becomes neutral just above the stellar surface and can therefore perfectly shield the disk material.

2. Model Calculations

Our empirical latitude dependent hydrogen density distribution in the non-spherically symmetric wind results from the latitude dependence of the velocity and of the mass flux. It accounts for the observed density ratio of $10^2 - 10^3$ between equator and pole as well as for the observed density concentration towards the equator which leads to a disk-like structure of opening angle $20° - 40°$ (Zickgraf 1990; 1992).

With such a density distribution we calculate the Strömgren radii of H and He in the on-the-spot approximation around Hen S 65, a B[e] supergiant in the Small Magellanic Cloud. The results for the Strömgren radii of H and He for three different models are shown in the left panel of Fig. 1. We find that in equatorial regions hydrogen becomes neutral very close to the stellar surface forming a neutral disk. These results are upper limits (for more details see Kraus & Lamers 2003). The right panel of Fig. 1 shows the equatorial ionization fractions of H and He that result from the exact solution of the ionization balance

https://doi.org/10.1017/S007418090019535X Published online by Cambridge University Press

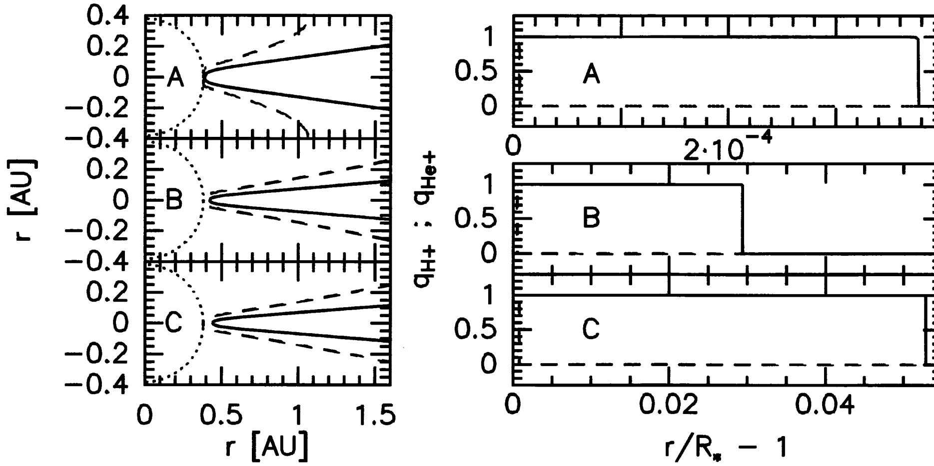

Figure 1. Strömgren radii (left panel) and ionization fractions (right panel) for H (solid line) and He (dashed line) in the equatorial region. All models are for a density ratio of 10^3 and a polar and equatorial wind velocity of 2000 km s^{-1} and 20 km s^{-1}, respectively. The equatorial mass flux is in model A a factor of 10 higher than in the other models. The total mass loss rate for model A is $2.4 \cdot 10^{-5} M_\odot$ yr^{-1}, and $2.4 \cdot 10^{-6} M_\odot$ yr^{-1} for models B and C. The electron temperature in model A and B is 10^4 K, and $1.5 \cdot 10^4$ K in model C. The dotted line in the left panel represents the stellar surface.

equations. It is clearly visible that the turn-over from ionized to neutral happens very near the stellar surface.

3. Conclusions

Equatorial winds of B[e] supergiants can become neutral just above the stellar surface forming a neutral disk in which molecules and dust can form. The existence of such a neutral disk is not unique for the B[e] supergiants. It was also proposed for the luminous blue variable star AG Car (Nota et al. 2002) and for the peculiar B[e] star MWC349 (Kraus et al. 2000) which both possess CO very near the hot central star.

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