ROTATIONALLY INDUCED TURBULENT DIFFUSION IN EARLY B-TYPE STARS: THEORY AND OBSERVATIONS

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Available observational data indicate that some kind of additional mixing is present in radiative envelopes of O and early B-type stars. Because of these stars are known to be the fastest rotators amongst all normal stars, the most probable candidate for the role of additional mixing in their interiors is rotationally induced turbulent diffusion discovered by Zahn (1983, 1992). Recently Denissenkov (1993a,b) calculated evolution of massive main sequence (MS) stars with turbulent diffusive mixing in order to explain atmospheric abundance peculiarities in OB-stars. This note summarizes the main results which have been obtained.

Early B-type stars with masses around 10 $M_{\odot}$

1) The observational correlation of the N overabundance with the relative stellar age found earlier by Lyubimkov (1984) and confirmed recently by Gies & Lambert (1992) has been theoretically reproduced.

2) A possible explanation of the atmospheric microturbulence in B-stars has been proposed for the first time (Fig. 1).

3) It has been shown that turbulent diffusion in MS B-stars can transport Na synthesized in the convective core into the radiative envelope, which could be responsible for the anomalous Na excesses observed in F-K supergiants.

Luminous OB-stars with spectroscopic masses 10 to 50 $M_{\odot}$

One of the most unexpected contradictions between theory of evolution and observations of massive MS stars revealed during the last few years seems to be the so-called "mass discrepancy". It has been found that masses of luminous OB-stars determined from spectroscopic analysis $M_{\rm sp}$ are systimaticaly higher than those obtained by comparing the stars' location in the HR diagram with theoretical evolutionary tracks $M_{\rm ev}$. Besides, in some of these stars large atmospheric helium abundances $\varepsilon_{\rm He} \geq 0.16$ have been detected, what in addition gave rise to the "helium discrepancy" problem (see Herrero et al. 1992 and references therein).

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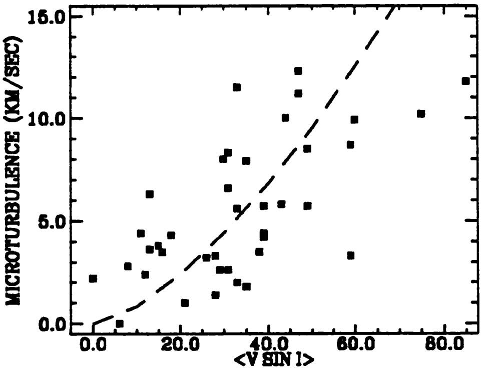

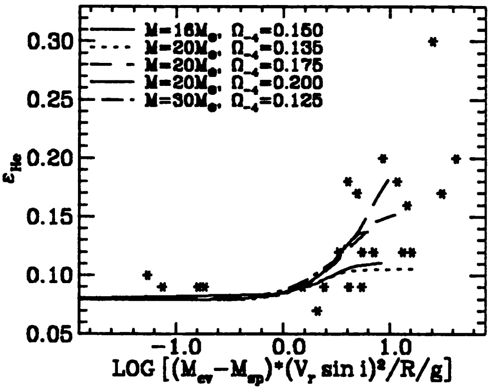

Fig. 1. Correlation between microturbulent and projected rotational velocities in the atmospheres of B-stars (squares) and theoretical dependence of the turbulent diffusion velocity at the surface of a model star on its rotation rate (dashed line). The atmospheric microturbulence in B-stars seems to be identical with Zahn's rotationally induced turbulence.

Fig. 2. Comparison of the observational (points) and theoretical (curves) dependences of the atmospheric helium abundance in OB-stars on the parameter characterising the efficiency of turbulent diffusive mixing.

Denissenkov (1993b) has proposed a model for massive MS stars that quantitatively accounts for these discrepancies. The radiative envelope of the model consists of two zones being mixed by rotationally induced turbulent diffusion on the MS. The rate of mixing in the outer zone is assumed to be substantially lower than that in the inner zone. Both, the mass and helium discrepancy, have been shown to be due to helium enrichment in the envelope produced by turbulent diffusion. In particular, the theoretical dependence of $\varepsilon_{\rm He}$ on the parameter $\log[(M_{\rm ev} - M_{\rm sp})(V \sin i)^2/R/g]$, which estimates the efficiency of turbulent diffusive mixing, has turned out to approximate very well the corresponding observational correlation in OB-stars (Fig. 2).

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