Wolf-Rayet Phenomena in Massive Stars and Starburst Galaxies
Proceedings IAU Symposium No. 193, ©1999 IAU
K.A. van der Hucht, G. Koenigsberger & P.R.J. Eenens, eds.

Shear-turbulence in rotating massive stars

Eugene Staritsin

Astronomical Observatory, University of Ural,
51 Lenin St., Ekaterinburgh 620083, Russia

Abstract. Shear-turbulence in a radiative envelopes of rotating main sequence massive stars transports angular momentum from the deeper layers to the stellar surface. This process enlarges the influence of rotation on the stellar radius. As a result, the width of the main sequence increases.

The theory of shear-turbulence in stars subject to the differential shellular rotation is developed by Zahn (1992). We study the role of angular momentum transport in the turbulent radiative envelope of a $16\,M_\odot$ star, neglecting meridional circulation and other possible transport mechanisms. We suggest rigid rotation in the convective core and a linear fall of angular velocity from the convective core boundary to the stellar surface in the zero-age model. Several values were taken for the initial ratio of the convective core angular velocity to the stellar surface one. The initial linear velocity in the equatorial plane was taken equal to $\sim 200\,\mathrm{km\,s^{-1}}$. Envelope expansion during the evolution produces differential rotation also.

The upper boundary of the turbulent envelope coincides with the stellar surface. The lower boundary stays at the position of the initial convective core boundary. Shear-turbulence can not penetrate to the layers with the molecular mass gradient. Nuclear reactions at the turbulent envelope bottom proceed with very low rates. Mixing of chemical species in the turbulent envelope is not appreciable. The turbulence transports the angular momentum from the deep interior of the star to the upper layers. The time-scale of the angular momentum transport coincides with the main sequence life-time. Stellar radius changing during the evolution is determined by the decreasing hydrogen content due to the nuclear burning in the convective core, and by increasing angular momentum in the upper layers due to the angular momentum transport in the turbulent envelope. The maximum values of the $16\,M_\odot$ stellar radius on the main sequence in the non-rotating case and in the case of initial rigid rotation are $10.5\,R_\odot$ and $11.4\,R_\odot$, respectively. In the case of initial non-rigid rotation, the stellar radius increase is even larger. As a result, the main sequence width enlarges.

References

Zahn, J.-P. 1992, A&A 265, 115