Spectroscopic and physical parameters of Galactic O-type stars. II. Observational constraints on projected rotational and extra broadening velocities as a function of fundamental parameters and stellar evolution.

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Rotation is of key importance for the evolution of massive stars, including their fate as supernovae or Gamma-ray bursts. However, the rotational velocities of OB stars are difficult to determine. Based on our own data for 31 Galactic O stars and incorporating similar data for 86 OB supergiants from the literature, we investigated the properties of rotational and extra line-broadening as a function of stellar parameters and put constrains on model predictions about the evolution of stellar rotation. Fundamental stellar parameters were determined by means of the
code FASTWIND. Projected rotational and extra broadening velocities, originate from a combined Fourier transform + Goodness-of- fit method. Model calculations published previously were used to estimate the initial evolutionary masses.
Our analysis shows that the sample O stars with initial masses larger than 50~Msun rotate with less that 26% of their break-up velocity, and they also lack slow rotators (vsini < 50~kms). For the more massive stars (Minit > 35 Msun) on the hotter side of the bi-stability jump, the observed and predicted rotational rates agree quite well; for those on the cooler side of the jump, the measured velocities are systematically higher than the predicted ones. In general, the derived extra-broadening velocities decrease toward cooler Teff, whilst for later evolutionary phases they appear, at the same vsini, higher for high-mass stars than for low-mass ones. None of the sample stars shows extra broadening velocities larger than 110~kms. For the majority of the more massive stars, extra broadening either dominates or is in strong competition with rotation. The main implications of our results are at least twofold: i) when appearing at or close to the zero-age main sequence, most of the single and more massive stars may rotate slower than previously thought; (ii) model predictions for the evolution of rotation in hot massive stars may need to be updated.

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