Rotating massive O stars with non-spherical 2D winds

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We present solutions for the velocity field and mass-loss rates for 2D axisymmetric outflows, as well as for the case of mass accretion through the use of the Lambert W-function. For the case of a rotating radiation-driven wind the velocity field is obtained analytically using a parameterised description of the line acceleration that only depends on radius r at any given latitude theta. The line acceleration g(r) is obtained from Monte-Carlo multi-line radiative transfer calculations. The critical/sonic point of our equation of motion varies with latitude theta. Furthermore, an approximate analytical solution for the supersonic flow of a rotating wind is derived, which is found to closely resemble the exact solution. For the simultaneous solution of the mass-loss rate and velocity field, we use the iterative method of our 1D method extended to the non-spherical 2D case. We apply the new theoretical expressions with our iterative method to the stellar wind from a differentially rotating 40 M_sun O5-V main sequence star as well as to a 60 M_sun O-giant star, and we compare our results to previous studies that are extensions of the Castor et al. (1975, ApJ, 195, 157) CAK formalism. Next, we account for the effects of oblateness and gravity darkening. Our numerical results predict an equatorial decrease of the mass-loss rate, which would imply that (surface-averaged) total mass-loss rates are lower than for the spherical 1D case, in contradiction to the Maeder & Meynet (2000, A&A, 361, 159) formalism that is oftentimes employed in stellar evolution calculations for rotating massive stars. To clarify the situation in nature we discuss observational tests to constrain the shapes of large-scale 2D stellar winds.

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