The impact of mass-loss on the evolution and pre-supernova properties of red supergiants

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The post main-sequence evolution of massive stars is very sensitive to many parameters of the stellar models. Key parameters are the mixing processes, the metallicity, the mass-loss rate and the effect of a close companion.
We study how the red supergiant lifetimes, the tracks in the Hertzsprung-Russel diagram (HRD), the positions in this diagram of the pre-supernova progenitor as well as the structure of the stars at that time change for various mass-loss rates during the red supergiant phase (RSG), and for two different initial rotation velocities. Stellar models are computed with the Geneva code for initial masses between 9 and 25 M$_odot$ at solar metallicity (Z=0.014) with 10 times and 25 times the standard mass-loss rates during the red supergiant phase, with and without rotation. The surface abundances of RSGs are much more sensitive to rotation than to the mass-loss rates during that phase.
A change of the RSG mass-loss rate has a strong impact on the RSG lifetimes and therefore on the luminosity function of RSGs. An observed RSG is associated to a larger initial mass model, when enhanced RSG mass-loss rate models are used to deduce that mass. At solar metallicity, the enhanced mass-loss rate models do produce significant changes on the populations of blue, yellow and red supergiants. When extended blue loops or blue ward excursions are produced by enhanced mass-loss, the models predict that a majority of blue (yellow) supergiants are post RSG objects. These post RSG stars are predicted to show much smaller surface rotational velocities than similar blue supergiants on their first crossing of the HR gap. Enhanced mass-loss rates during the red supergiant phase has little impact on the Wolf-Rayet (WR) populations. The position in the HRD of the end point of the evolution depends on the mass of the hydrogen envelope. More precisely, whenever, at the pre-supernova stage, the H-rich envelope contains more than about 5% of the initial mass, the star is a red supergiant, and whenever the H-rich envelope contains less than 1% of the total mass the star is a blue supergiant. For intermediate situations, intermediate colors/effective temperatures are obtained. Yellow progenitors for core collapse supernovae can be explained by the enhanced mass-loss rate models, while the red progenitors are better fitted by the standard mass-loss rate models.

Reference: in press for Astronomy and Astrophysics
Status: Manuscript has been accepted

Weblink: http://arxiv.org/abs/1410.8721

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