Massive star evolution : rotation, winds, and overshooting vectors in the Mass-Luminosity plane
I. A calibrated grid of rotating single star models

Erin R. Higgins (1,2,3,4) & Jorick S. Vink (1,4)

1 - Armagh Observatory and Planetarium, College Hill, Armagh BT61 9DG, N. Ireland
2 - Queenâ€™s University of Belfast, Belfast BT7 1NN, N. Ireland
3 - Dublin Institute for Advanced Studies, 31 Fitzwilliam Place, Dublin, Ireland
4 - Kavli Institute for Theoretical Physics, University of California, Santa Barbara, CA 93106, USA

We aim to constrain massive star evolution models using the unique testbed eclipsing binary HD166734 with new grids of MESA stellar evolution models, adopting calibrated prescriptions of overshooting, mass loss, and rotation. We introduce a novel tool: the "mass-luminosity plane" or "M-L plane", as an equivalent to the traditional HR diagram, utilising it to reproduce the testbed binary HD166734 with newly calibrated MESA stellar evolution models for single stars. We can only reproduce the Galactic binary system with an enhanced amount of core overshooting (alpha = 0.5), mass loss, and rotational mixing. We can utilise the gradient in the M-L plane to constrain the amount of mass loss to 0.5 - 1.5 times the standard Vink et al. 2001 prescriptions, and we can exclude extreme reduction or multiplication factors. The extent of the vectors in the M-L plane leads us to conclude that the amount of core overshooting is larger than is normally adopted in contemporary massive star evolution models. We furthermore conclude that rotational mixing is mandatory to get the nitrogen abundance ratios between the primary and secondary components to be correct (3:1) in our testbed binary system. Our calibrated grid of models, alongside our new M-L plane approach, present the possibility of a widened main sequence due to an increased demand for core overshooting. The increased amount of core overshooting is not only needed to explain the extended main sequence, but the enhanced overshooting is also needed to explain the location of the upper-luminosity limit of the red supergiants. Finally, the increased amount of core overshooting has -- via the compactness parameter -- implications for supernova explodibility.

Reference: arXiv:1811.12190
Status: Manuscript has been accepted

Weblink: https://arxiv.org/abs/1811.12190

Comments: 14 pages, 19 figures, accepted for publication by Astronomy & Astrophysics

Email: erin.higgins@armagh.ac.uk