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Joint Discussion 5 Calibrating the top of the stellar *M* - *L* relation

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Rationale and overview

The goal of this Joint Discussion is to bring together theorists and observers from the stellar and extragalactic communities to discuss the properties of the most massive stars and the implications for cosmological studies. We will focus on a set of themes that follow from fundamental stellar astronomy, such as mass determinations in binary stars, to recent modeling of atmospheres and evolution, to the significance of massive stars for the ecology of the host galaxy, and finally to a critical assessment of the properties of the first generation of stars in the universe.

Until now, few efforts have been devoted to aggressively searching for the most massive stars. Massey *et al.* (2007) have looked at the most luminous O-type stars on the main sequence, with mass estimates for several O3-type stars in the surprisingly broad, low range from some $35-60\,M_\odot$. Rauw *et al.* (2004) and Rauw *et al.* (2005) have concentrated on luminous WR stars in the 7th Galactic WR Catalogue (van der Hucht 2001), and recent light curve measurements for the WN6ha + WN6ha system WR20a lead to component masses close to 83 and $82\,M_\odot$, the highest binary-inferred masses to date. Moffat *et al.* (2007) are concentrating on the most luminous, H-rich WNL stars mainly in the LMC and NGC 3603 in the Galaxy. It thus remains an open issue how much above the binary-inferred maximum $80\,M_\odot$ the most massive stars may actually be.

Optical interferometry is entering a new age with several ground-based long-baseline observatories now making observations of unprecedented resolution. Interferometers bring a new level of resolution to bear on massive spectroscopic binaries, enabling the full extraction of the physical parameters for the component stars with high accuracy. This will be an opportunity to determine hundreds of fully three-dimensional orbits in absolute units, when interferometric results are combined with spectroscopic orbits, thus accurately determining masses, diameters, and distances (hence luminosities) of tens of massive binary stars through their orbital parallaxes.

In contrast to such direct observations of masses, based on Keplerian orbits in binaries, which have never yielded values above 85 $M_\odot$, less direct techniques based on spectroscopic analyses tend to give a fairly large spread of masses. For extremely luminous stars like η Carinae and the Pistol Star, keeping within the Eddington limit requires masses near 100 $M_\odot$. Up-to-date atmospheric models accounting for mass-loss and line-blanketing seem to indicate that the long-standing mass discrepancy (i.e., the problem that atmospheric masses are systematically lower than the evolutionary ones) has still not been fully resolved. Since mass is the most fundamental stellar parameter, such a discrepancy is intolerable, and its theoretical origin needs to be explored.

While determining the mass of the most massive stars and calibrating the top of the mass-luminosity relation are meritorious in their own right, stellar masses are a central theme in current extragalactic astronomy as well. The top end of the stellar initial mass function is imprinted in the observed spectra of distant populations, and our knowledge of the stellar content relies on local calibrations. A comparison of the properties of the most massive stars in the Galaxy and the Magellanic Clouds might indicate a trend of higher masses with lower metal abundance. The subject has received particular interest from research aimed at understanding and predicting the properties of distant stellar populations, which are thought to be the powering sources of Lyman-break or SCUBA galaxies.

A common theme of contemporary cosmology is the quest for the first generation of stars formed in the universe. Such stars are thought to be the supermassive cousins of the massive stars studied locally. Local calibrations of the fundamental stellar parameters will provide much sought guidance for cosmological models. Modeling massive metal-free stars poses major challenges due to yet unexplored phenomena such as rotation and mass loss in such extreme environments. A particularly important issue regards the importance of episodes of super-Eddington, continuuum-driven mass loss (such as occurs in η Carinae and other Luminous Blue Variable stars), which can reduce the evolutionary mass even in the absence of a substantial metal-line-driven stellar wind. With rapid rotation a bipolar shaping of the mass ejection (such as seen in the Homunculus nebula of η Carinae) can reduce the associated angular momentum loss, with potentially important consequences for leaving the rapidly rotating core central to the collapsar model for γ-ray bursts.

Scientific Organizing Committee

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