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Massive Star Formation in the Sparsest Environments

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Abstract. There is growing evidence that massive stars sometimes form in extremely sparse environments. The RIOTS4 survey presents a variety of evidence supporting this scenario, including a sample of 14 OB stars in the Small Magellanic Cloud (SMC) that appear to have formed in situ as field stars. This is based on the presence of dense, symmetric HII regions hosting apparent non-runaway stars. We also present a spatially complete IMF of SMC field OB stars for masses $> 7\ M_\odot$, showing that the slope is much steeper than the Salpeter value. The binary fraction among field OB stars is also the same as in clusters, based on a RIOTS4 subsample. These results suggest a relative, but incomplete, suppression of massive star formation in the sparsest regimes.

Keywords. stars: formation, stars: early-type, binaries: spectroscopic, galaxies: star clusters, galaxies: stellar content, Magellanic Clouds

1. Introduction

The Runaways and Isolated O-Type Star Spectroscopic Survey of the SMC (RIOTS4) is a spatially complete survey of uniformly selected field OB stars covering the entire star-forming body of the SMC (Lamb et al. 2015). We used the IMACS and MIKE spectrographs at Magellan to observe 374 field OB stars selected to be at least 28 pc from any other OB stars. The survey is complete above 20 $M_\odot$ and yields quantitative distributions for the stellar masses, radial velocities, and $v \sin i > 150$ km s^{-1}. We also characterize the properties of classical Oe stars and their spectral type distribution (Golden-Marx *et al.*2015) and we identify a new, dust-poor population of B[e] supergiants (Graus *et al.*2012).

Candidate Isolated SF: RIOTS4 reveals field massive stars that appear to have formed in relative isolation (Oey *et al.*2013). In particular, we identify 14 OB stars that are centered within symmetric, round HII regions with no evidence of bow shocks or significant transverse velocity (Figure 1). Furthermore, their radial velocities are within 10 km s^{-1} of major HI components in the line of sight. These objects typically have < 8 main sequence companions in projection down to $I = 20.5$, and thus represent extremely sparse massive star formation. Of the 14 targets, 5 are consistent with being non-runaway OB stars that formed in true isolation.

Field IMF: The field OB star IMF is also consistent with field massive stars forming in situ. We find that the upper IMF is much steeper, having a power law slope of $\Gamma = -2.3 \pm 0.4$, where the Salpeter (1955) value is -1.35 (Lamb *et al.*2013). We find the same steep slope from both our RIOTS4 data and OGLE photometry down to 7 $M_\odot$. Since O stars have a higher runaway frequency than B stars (Blaauw 1961; Stone 1991), the steep field IMF argues against runaways dominating this population. A steep field IMF is consistent with the field being dominated by star formation in tiny clusters whose total masses are so low that the most massive stars cannot form (Lamb *et al.*2015).

Field Binaries: RIOTS4 included binary monitoring of 29 stars over $9 - 16$ epochs. These yield an observed binary frequency of 0.52 ± 0.09 (Lamb *et al.*2015), similar to the frequency in clusters (e.g., Sana & Evans 2011; Kobulnicky *et al.*2014). Since runaways are much less likely to be binaries, our preliminary result suggests that these massive binaries formed in situ in the

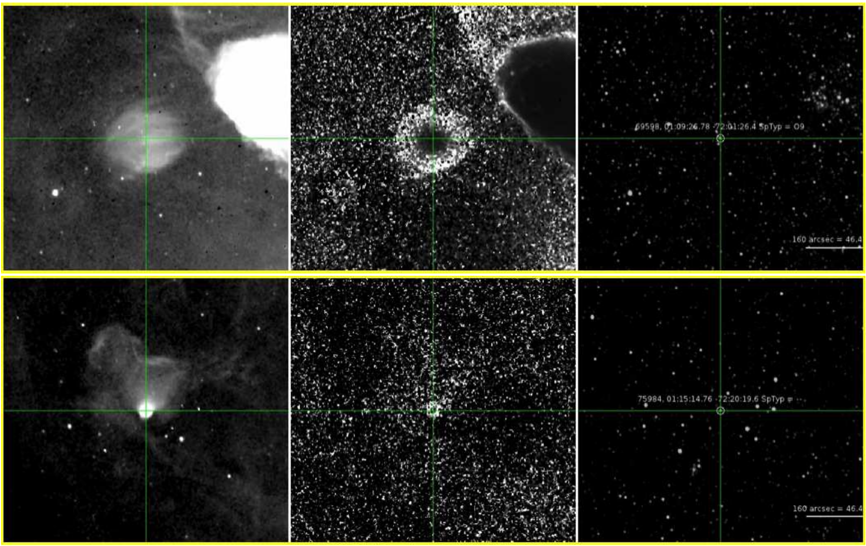

Figure 1. Example objects from Oey *et al.*(2013), stars 69598 (top) and 75984 (bottom); IDs are from Massey (2002). The left, center, and right panels show Hα, [SII]/[OIII], and green continuum, respectively. White corresponds to high values in all images, and the scale bar shows a distance of 160 arcsec, or 46.4 pc at the SMC distance.

field and furthermore, that runaways are a relatively minor constituent of the field as defined in our sample.

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