Massive Stars Near and Far
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Luminous red supergiants in the Magellanic Clouds

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Abstract. There is evidence that some red supergiants (RSGs) experience phases of episodic mass-loss. These episodes yield more extreme mass-loss rates, further stripping the envelope of the RSG, significantly affecting the further evolution towards the final collapse of the star. Mass lost through RSG outbursts/superwinds will flow outwards and form dust further out from the surface and this dust may be detected and modelled. Here, we aim to derive the surface properties and estimate the global properties of Mid-IR bright RSGs in the Magellanic Clouds. These properties will then be compared to evolutionary predictions and used for future spectral energy distribution fitting studies to measure the mass-loss rates from present circumstellar dust.

Keywords. massive stars, mass-loss, stellar parameters

1. Observing plan and modelling

The presence of circumstellar dust reveals past mass-loss events of RSGs. We aim to model such dusty RSGs and learn about their properties. For this, we selected previously unstudied, bright and dusty supergiant candidates using colour-magnitude criteria from the Near-IR, Mid-IR and optical colour-magnitude diagrams (see Fig. 1, top panel). For eleven objects satisfying the criteria, we obtained Magellan/MagE spectra ($R = \frac{\lambda}{\delta\lambda} \sim 4000$). Eight objects were classified as RSGs. We modelled these spectra using MARCS atmospheric models (Gustafsson et al. 2008), to obtain the effective temperature, the optical extinction factor and the surface gravity through a minimal χ^2 fitting routine (see Fig. 1, bottom panel for an example). More specifically, we have used the Ca II triplet to constrain the surface gravity, the molecular TiO bands to constrain the effective temperature and the slope of the spectrum to derive the extinction. Subsequently, using the K-band magnitude, we have estimated global properties such as the stellar luminosity and radius. The full analysis is presented in de Wit et al. (submitted).

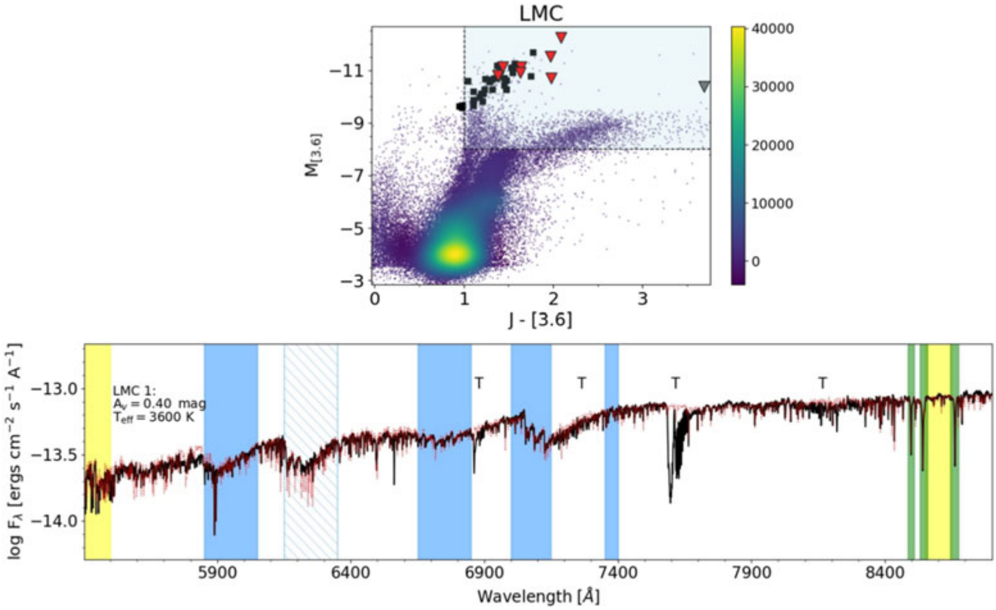

Figure 1. Top: Colour-magnitude diagram of targets in the LMC. The blue shade highlights the applied selection criteria. The red triangles indicate the observed red supergiants in the LMC, whereas the black boxes show red supergiants of similar studies. The SMC diagram looks similar but is not shown here. Bottom: Example of a best-fit spectrum. The model spectrum is shown in red and the observed spectrum is shown in black. Shaded regions were included in the analysis to calculate the effective temperature (blue), optical extinction (yellow) and surface gravity (green). The best-fit properties are indicated in the top left.

2. Main results

In de Wit et al. (submitted), we will present the full table containing the spectral types and derived surface properties of the observed RSGs. Two other evolved massive stars have been identified in this work. One is a new yellow supergiant (F8I), and we re-classified a known SgB[e] from B8I[e] to A0I[e]. In this work, we derived typical RSG effective temperatures in the range of 3500-3750 K, with extinction factors ranging from 0.3-1.0 mag, which is low for RSGs due to the contribution of circumstellar dust to the optical extinction. However, the reason for this has been reported frequently and attributed to the temperature structure used in the MARCS models, such that using the models to fit the optical TiO bands results in unreasonable extinction factors (Davies et al. 2013).

One of the stars studied in the LMC, [W60]B90, lies at the bright end of the RSG luminosity function (Davies et al. 2018) at $\log(L_*/L_\odot) \sim 5.5$ and has a stellar radius around 1400 $R_\odot$. These extreme properties put this object in the range of the largest star known in the LMC, WOH G64. WOH G64 is a well studied dust enshrouded RSG with a current estimate on the radius around 1550 $R_\odot$ (Levesque et al. 2009; Beasor & Smith 2022). A follow up to our study is to employ SED fitting techniques (i.e. DUSTY; Ivezic & Elitzur 1997) to derive the mass-loss rate of [W60]B90 and see whether this object is just as extreme. In a separate future work we aim to extend the analysis here, by modelling ~ 200 newly obtained FORS2 spectra of RSGs. These RSGs are located in various nearby galaxies targeted by the ERC ASSESS project on episodic mass loss in evolved massive stars (Bonanos et al. 2022). The aim is to model and study their surface and mass-loss properties and compare them as a function of metallicity.

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