Stars and their variability observed from space
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GALACTIC RED SUPERGIANTS IN GAIA DR2

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Abstract. We present the recently published catalogue of known Galactic late-type stars of luminosity class I that have a counterpart in the *Gaia* DR2 catalog.

Keywords: infrared: stars, stars: supergiants, evolution

1 Introduction

By the term "red supergiant" (RSG) astronomers usually refer to a star with a specific type of internal structure, and not just to its surface temperature or luminosity. RSG stars are cold massive stars "which do not develop a strongly electron-degenerate core until all exoergic reactions have run to completion at the centre" (Iben 1974). Temperatures are below 4200 K (K0), and may be even colder than 3000 K (e.g., μ Cep, whose spectral type is M7.5). Luminosities are typically above $\log(\frac{L}{L_\odot})= 4$, though the lower limit deepends on the treatment of rotation and convection; it can be as faint as $\log(\frac{L}{L_\odot})= 3.5$ (Ekström et al. 2012). RSGs are the brightest stars of a galaxy at infrared wavelengths being luminous and intrinsically cold, they are easily detectable at distances of a few megaparsecs. Their nucleosynthesis, stellar winds, and ultimate explosions as supernovae are fundamental processes for understanding a galaxy's chemical enrichment; they are tracers of star-formation episodes dating back 4.5–30 Myr. Despite their importance, we know only a small fraction of galactic RSGs; a census of them is seriously incomplete. Indeed, even though the Milky Way is the closest laboratory of resolved stellar populations, their detections are hampered by our location in the Disk, by dust obscuration in observations, and by uncertainties in distances. Furthermore, astronomical luminosity classes are observational quantities that cannot necessarily be translated into internal stellar structures, the major problem being the overlap in luminosity of RSGs and SGB stars.

We have searched in *Gaia* DR2 (Gaia Collaboration et al. 2018) for matches to the $\approx$ 1400 candidate Galactic RSGs collected and listed by Skiff (2014). We refer to these stars as candidate RSGs because they are reported in the literature at least once as cold stars of luminosity class I. In Messineo & Brown (2019) we published the catalog of known K–M class I stars with good quality Gaia DR2 parallaxes. We cross-matched the catalog with historical catalogs of RSGs, such as those of Humphreys (1978), Elias et al. (1985), and Jura & Kleinmann (1990) (the references are listed in the catalog). An average spectral type or recently revised spectral type was adopted for every entry, and the stellar temperature was estimated by assuming the temperature scale of Levesque et al. (2005). Parallaxes were found for 1342 stars, but after having applied a data filtering (RUWE $<$ 2.7 and $\varpi/\sigma_\varpi > 4$,see Lindegren et al. 2018)*), the sample was reduced to 889 stars.

Photometric measurements were retrieved from the 2MASS, CIO, MSX, WISE, MIPSGAL, GLIMPE and NOMAD catalogues; to validate the matches, we used positional distances as well as a visual inspection of the stellar energy distribution. By combining those magnitudes with the *Gaia* parallaxes, we were able to estimate the luminosities of the stars. We classified 30% of the stars as giants because their luminosities were fainter than the tip of the red-giant branch. We counted 43 stars (5%) brighter than $\log(\frac{L}{L_\odot})= 4.74$ (i.e., $M_{\rm bol}=-7.1$ mag), which is the AGB luminosity limit. By using the stellar tracks of Ekström et al. (2012) we estimated that at least the 41% of the stars that were brighter than $M_{\rm bol}= -5.0$ mag and of spectral type earlier than M4 were probably more massive than 7 $M_\odot$, making them probable RSGs. The catalogue treats the stars individually, but lists known associations with stellar clusters. Associations have traditionally been used to locate definite RSGs (e.g. Levesque et al. 2005), in the sense that a luminous and bright late-type star associated with a

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*see the online documentations *https://www.cosmos.esa.int/web/gaia/dr2-known-issues#AstrometryConsiderations*

population of evolved OB stars is certainly a massive star. Among the 889 stars with good parallaxes, 93 (10%) were associated with OB groups. Only 13% of all 1406 stras considered were reported as members.
The main focus of our exercise was to extract from *Gaia* DR2 a genuine sample of bright, luminous, cold stars. We derived the average magnitudes per spectral type and found that the stellar bolometric magnitudes correlated linearly with temperature in the range 3950–3600 K (see Fig. 1). We found that only 90 out of the 889 stars with good parallaxes (about 10%) were flagged as variables (Holl et al. 2018). Those variables tended to have later spectral types (K5–M7). 89 of them were classified automatically by the *Gaia* pipeline as long-period variables, showing an average variation in the G-band of 0.51 mag with a dispersion around the mean of 0.38 mag.

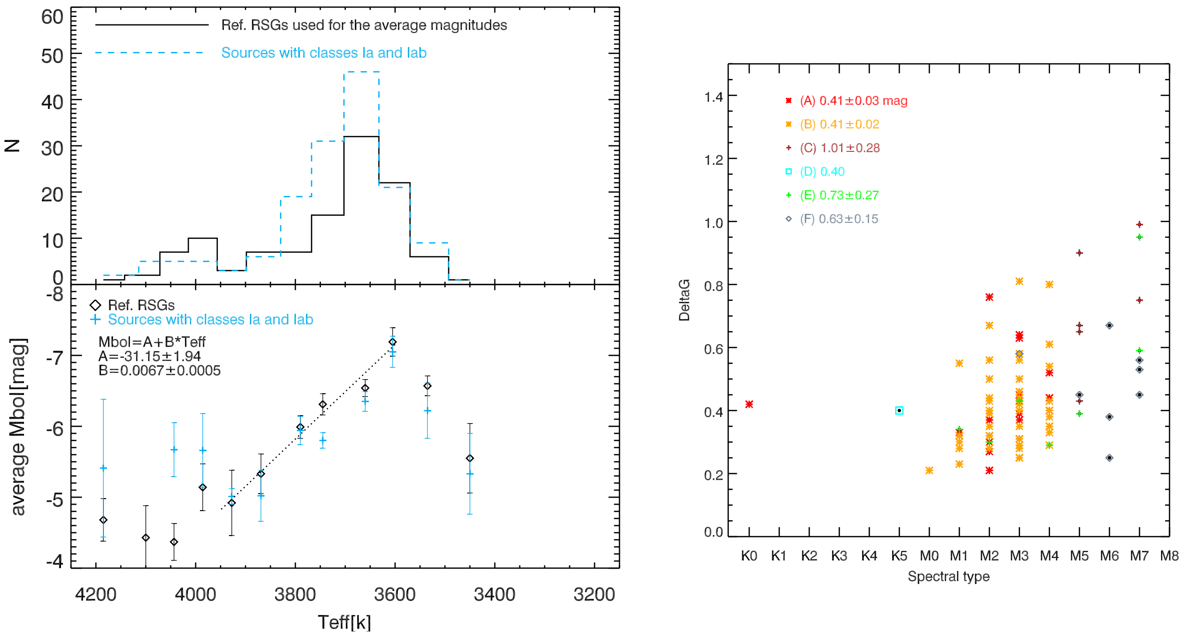

Fig. 1. Left Bottom panel: Average $M_{\rm bol}$ *vs.* $T_{\rm eff}$. Cyan crosses show the values for class Ia and Iab stars. Black diamonds indicate the values for the reference RSGs. **Left Top panel:** Histogram of the stars used to estimate the average magnitude per spectral type from stars with good parallaxes and $M_{\rm bol} < -3.6$ mag. **Right panel:** Differences beween the maximum and minimum magnitudes measured in G-band *vs.* spectral type. The legends list the average ΔG measured in the areas of the H–R diagram defined by Messineo & Brown (2019)

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