Estimating the gas and dust enrichment from carbon-rich stars in the Magellanic Clouds

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Physical context

Most of the stars in the Universe will end their evolution by losing their envelope during the **thermally pulsing asymptotic giant branch** (TP-AGB) phase, enriching the interstellar medium of galaxies with heavy elements, partially condensed into dust grains formed in their extended envelopes. **Among these stars, carbon-rich TP-AGB stars (C-stars) are particularly relevant for the chemical enrichment of the local and high-redshift galaxies.** At metallicity lower than solar, characteristic of the Magellanic Clouds (MCs), a large fraction of TP-AGB stars evolve through the carbon-rich phase, making the MCs the ideal sites to study the dust production of C-stars and their mass-loss rates.

Method

- Grain growth is coupled with a spherical symmetric, stationary wind, as described in Nanni et al. 2013, 2014 and with the code MoD (Groenewegen 2012; Ivezic&Elitzur 1997), which yields the spectra of C-stars reprocessed by dust (Nanni et al. 2016; Nanni 2019).
- The grids of spectra are employed to fit the spectral energy distribution of the C-stars in the MCs, and the quantities are derived without assuming, as usually done in the literature, the outflow expansion velocity (v_{exp}) and the gas-to-dust ratio (Ψ).

Results

- In figure 1 the Ψ derived for all the C-stars in the MCs is plotted as a function of the mass-loss rate. **The trend found suggests that dust forms more efficiently in denser environments**. While in the literature Ψ is often assumed to be 200 for C-stars, we derive a large range of values, from almost dust-free to heavily dust-enshrouded stars.
- The total dust production rates (DPRs) for the MCs are compared with the ones in the literature in table 1. For the Small Magellanic Cloud (SMC), the DPR we derived is in reasonable agreement with the one by Matsuura+13, while the DPRs of Boyer+12 and Srinivasan+16 are about 4 times lower than the one we derived.

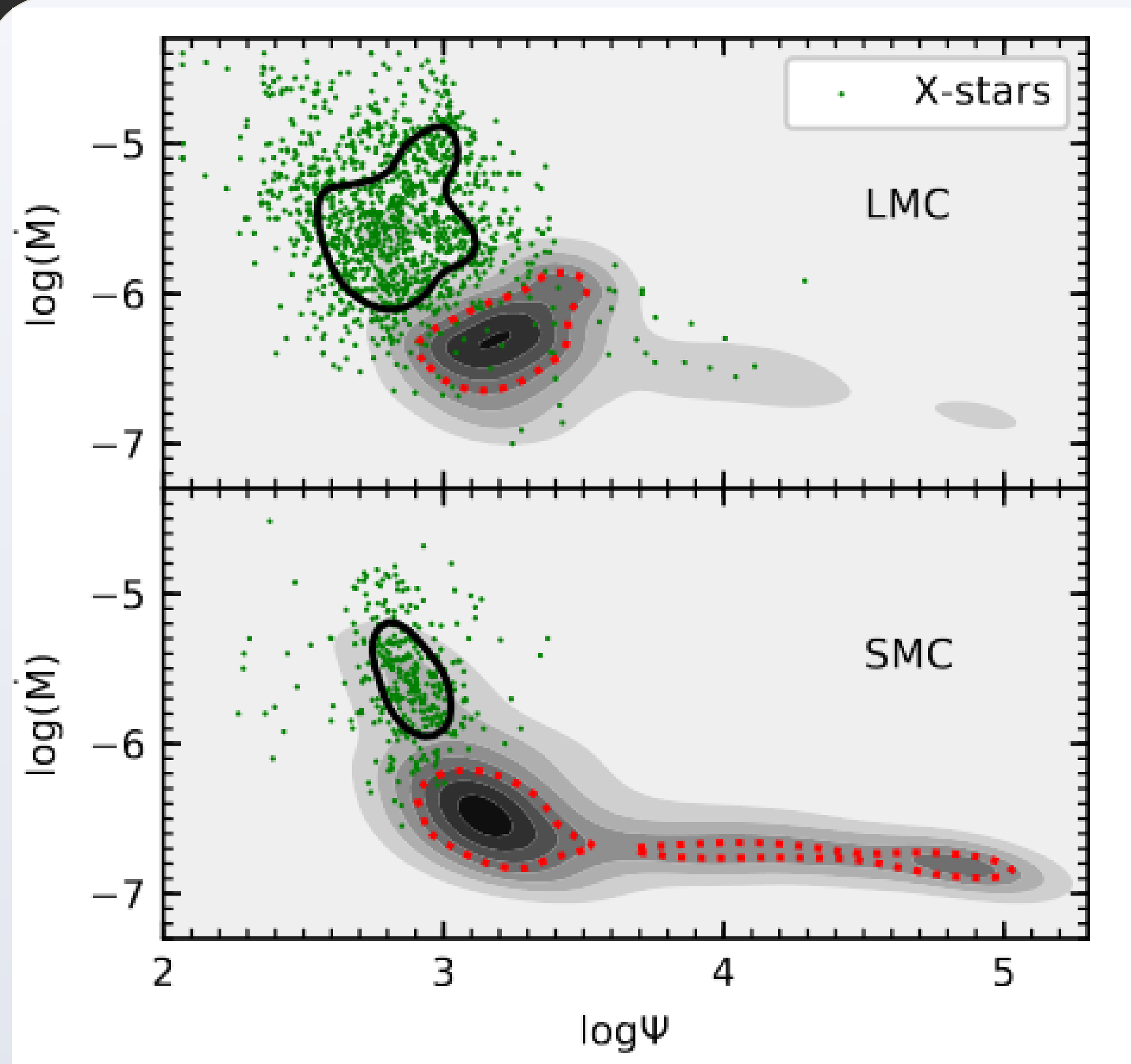

Figure 1: The gas-to-dust ratio (Ψ) as a function of mass-loss rate derived from the SED fitting of C-stars in the MCs. X-stars are the most extreme, dust-enshrouded stars.

	SMC DPRs [$M_\odot$/yr]	LMC DPRs [$M_\odot$/yr]
This work	$(2.88\pm 1.11) \times 10^{-6}$	$(1.94 \pm 0.51) \times 10^{-5}$
Boyer+12	$\approx 8.0 \times 10^{-7}$	-
Srinivasan+16	$\approx 7.5 \times 10^{-7}$	$\approx 1.0 \times 10^{-5}$
Matsuura+13	$\approx 4 \times 10^{-6}$	-
Riebel+12	-	$\approx 1.4 \times 10^{-5}$

Table 1: total DPRs for the MCs obtained from our analysis and compared with the ones in the literature.

Such a discrepancy is due to several factors, e.g. different grain sizes and v_{exp}. For the Large Magellanic Cloud (LMC) the DPR we obtained is in reasonable good agreement with the one derived by Riebel+12.

References

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