

JWST NIRCам and MIRI Reveal the Dust-Producing AGB Population of NGC 6822

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ABSTRACT

We present a photometric catalogue of the Local Group dwarf galaxy NGC 6822 based on deep *JWST* observations obtained with the Near-Infrared Camera (NIRCам) and Mid-Infrared Instrument (MIRI). Point-spread-function photometry and band-matching were performed with *starbug*. The resulting catalogue contains 864,114 NIRCам point sources and 17,235 MIRI detections, with 10,079 detected in both instruments. Blackbody fitting yields effective temperatures and bolometric luminosities for 119,621 stars, providing a detailed view of the resolved stellar content. Candidate evolved stars were selected from NIRCам–MIRI colour–magnitude diagrams, with the sample refined by removing resolved contaminants and excluding young stellar objects through spectral energy distribution (SED) fitting. The final sample of 1226 evolved stars was analysed using the Grid of Red Supergiant and Asymptotic Giant Branch Models (GRAMS), from which dust-production rates were obtained and carbon-rich or oxygen-rich asymptotic giant branch (AGB) classifications assigned via a likelihood-weighted comparison across the full model set. Across the *JWST* fields, evolved stars return $5.6 \times 10^{-7} M_{\odot} \text{ yr}^{-1}$ of dust to the interstellar medium, with oxygen-rich AGB stars contributing 60% and carbon-rich AGB stars 35%, despite the low metallicity of NGC 6822. The unexpectedly high oxygen-rich contribution indicates the presence of intermediate-mass AGB stars undergoing hot-bottom burning, in line with the recent star-formation history of NGC 6822. Dust-producing AGB stars exhibit a centrally concentrated carbon-rich population and a more extended oxygen-rich population. We also identify *JWST* colour relations that provide robust photometric estimators of dust-production rates for evolved stars.

Key words: galaxies: dwarf – galaxies: irregular – galaxies: individual (NGC 6822) – infrared: galaxies – infrared: stars – stars: AGB and post-AGB

Background

Stellar populations in local galaxies can be investigated by observing individual bright evolved stars.

Stars in some mass range can evolve to Carbon-rich Asymptotic Giant Branch stars (C-rich AGBs).

The ratio of C-rich/O-rich AGBs can be a useful observable to characterize a stellar population in a local galaxy.

Properties of NGC 6822	
Nominal centre point	19:44:56 -14:47:51
Distance	490 ± 40 kpc (Fusco et al. 2012)
Distance modulus ($m - M$) ₀	23.45
E(B-V)	0.35 ± 0.04 (Tantalo et al. 2022)
Metallicity	[Fe/H] = -1.2 (Lee et al. 2006)

MIRI Observation Properties	
Survey area (arcmin^2)	14.5
Total time (hr)	15.12
Filters	F770W, F1000W, F1500W, F2100W
Central λ (μm)	7.528, 9.883, 14.932, 20.563
FWHM at λ (pixel)	2.445, 2.982, 4.436, 6.127
Completeness limits at λ (mag)	20.43 19.41 16.80 16.86

NIRCам Observation Properties	
Survey area (arcmin^2)	29.0
Total time (hr)	4.80
Filters	F115W, F200W, F356W, F444W
Central λ (μm)	1.154, 1.990, 3.563, 4.421
FWHM at λ (pixel)	1.290, 2.129, 1.841, 2.302
Completeness limits at λ (mag)	25.60 24.58 23.21 23.09

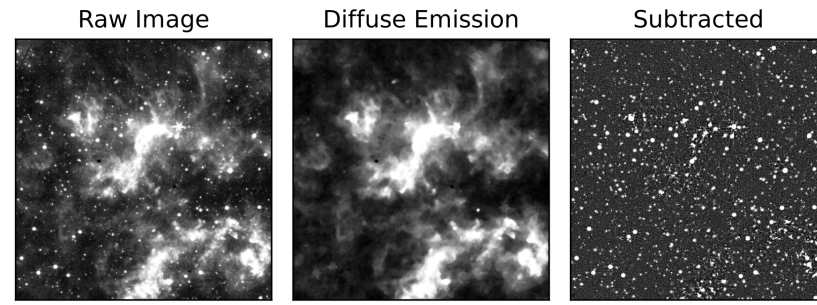
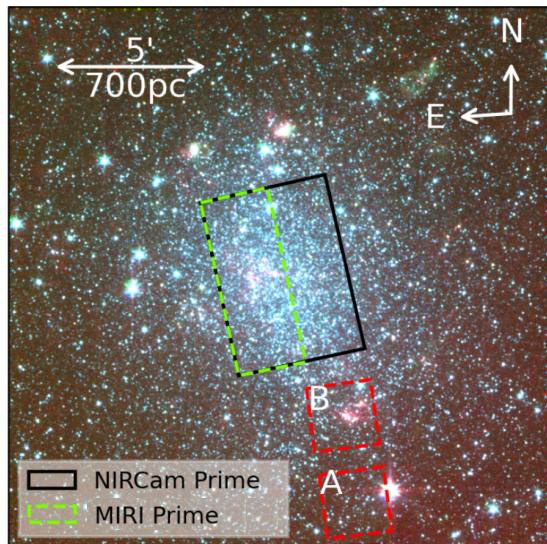


Figure 1. Diffuse-emission estimation for a single Stage-2 exposure of the dusty Spitzer-1 region of NGC 6822. The left panel shows the raw input array, the middle panel shows the result of *starbug2* –background, and the right panel shows the background-subtracted image on which PSF fitting is performed.

Figure 4. CMDs of NGC 6822 showing the evolved-star selection boundaries. Four CMDs are presented: F200W versus F115W–F200W, F770W versus F444W–F770W, F1000W versus F770W–F1000W, and F2100W versus F770W–F2100W. Selection boundaries are shown in red, with their numerical values listed in Table 5. Magnitude distributions are shown in the histograms to the right of each CMD; the top CMD uses a logarithmic scale due to the large number of sources, while the remaining histograms use linear scaling.

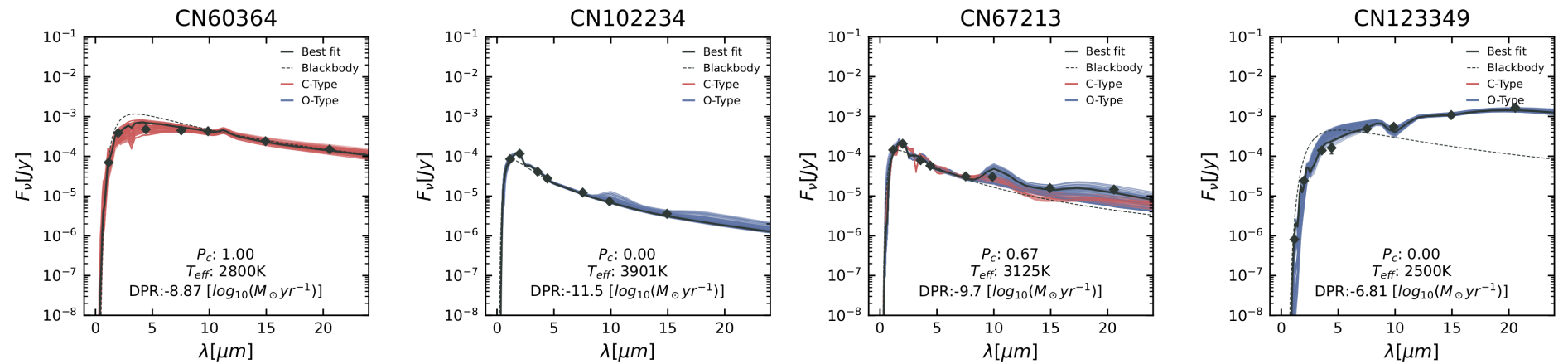
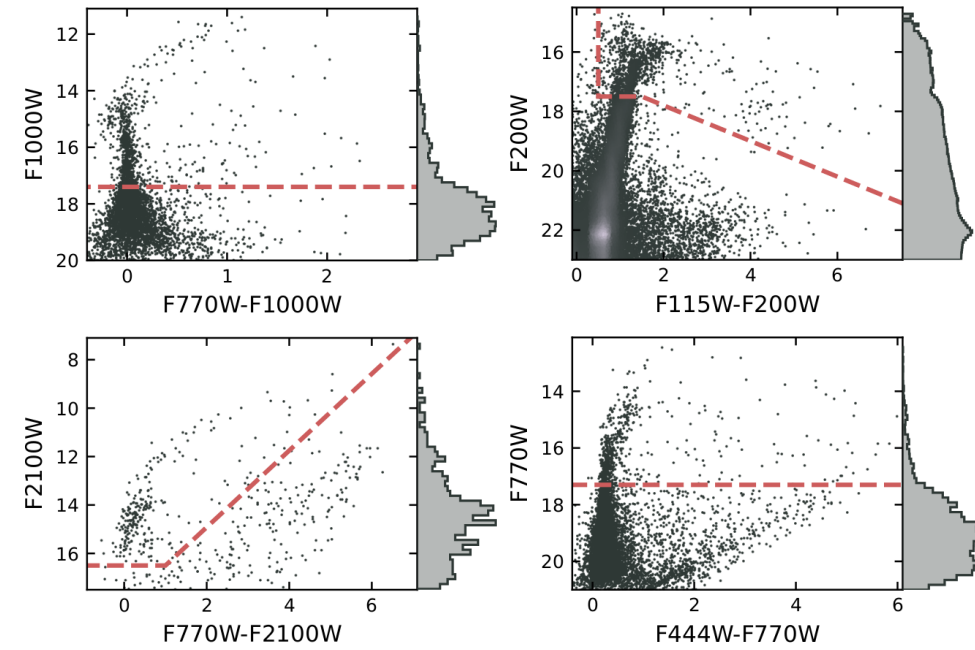


Figure 6. Four examples of GRAMS SED fitting for evolved sources in NGC 6822. Each panel shows the top 100 best-fitting GRAMS models to a given source (photometric points shown as black diamonds, with flux uncertainties where visible). Carbon-rich models are plotted in red and oxygen-rich models in blue. The solid black line indicates the best-fitting model, and the dashed line shows the best-fitting blackbody from Section 3.3.

Stellar Classification	Number	Sources with $\text{DPR} \geq 10^{-11.3}$	Total DPR [$M_{\odot} \text{ yr}^{-1}$]	Percentage of Total DPR
AGB	610	376	5.3×10^{-7}	95
C-AGB	191	180	1.9×10^{-7}	35
O-AGB	419	196	3.4×10^{-7}	60
RSG	253	61	7.5×10^{-9}	1
TRGB	363	106	2.4×10^{-8}	4
Total	1226	544	5.6×10^{-7}	

Figure 11. Global cumulative DPR from AGB stars as a function of stellar mass (M_*) for Local Group galaxies. Stellar masses are from McConnachie (2012). DPR measurements are shown for WLM, Pegasus dIrr, LGS 3 and Phoenix (assuming a gas-to-dust ratio of 200; Boyer et al. 2009), IC 1613 (Dell’Agli et al. 2016), the LMC (Riebel et al. 2012), the SMC (Srinivasan et al. 2016), IC 10 (Dell’Agli et al. 2017), and Sextans A and Leo A (Jones et al. 2018).

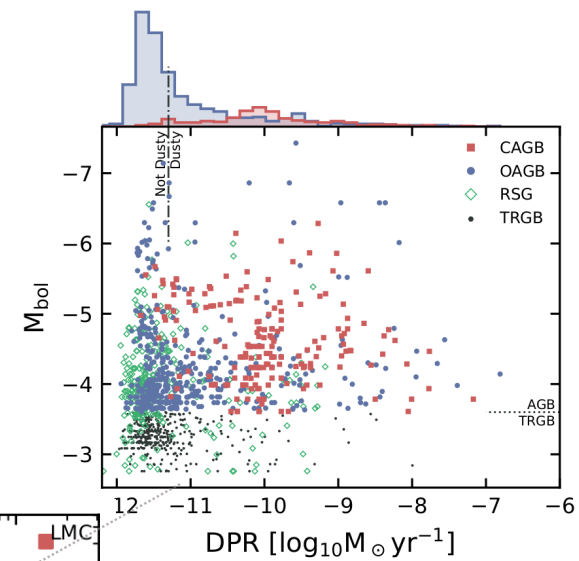
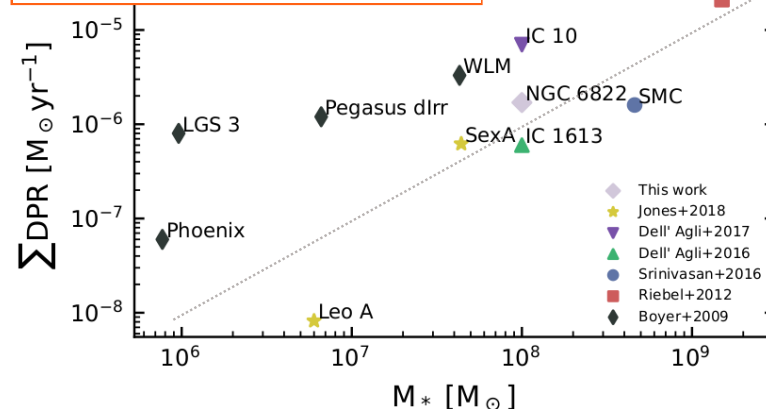


Figure 10. Dust-production rate (DPR) versus bolometric magnitude (M_{bol}). Oxygen-rich AGB stars are plotted in blue, carbon-rich AGB stars in red, RSG stars in green, and TRGB stars in black. The classical TRGB limit ($M_{\text{bol}} = -3.61$) and the boundary between dust-free and dust-producing stars are overlaid. The upper panel shows the distribution of DPR values for the oxygen-rich dust produced by O-AGB and RSG stars (blue) and for the carbon-rich dust produced by C-AGB stars (red).

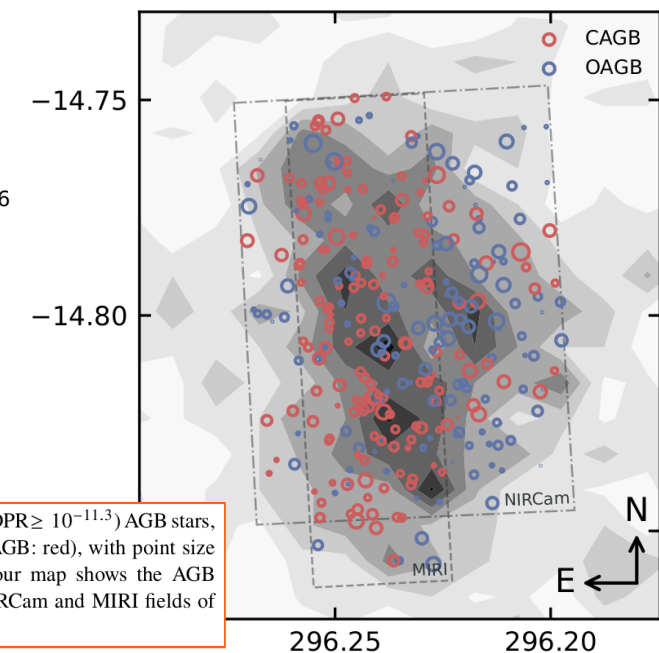


Figure 13. Spatial distribution of dust-producing ($\text{DPR} \geq 10^{-11.3}$) AGB stars, coloured by chemical subtype (O-AGB: blue; C-AGB: red), with point size scaled by individual DPR. The underlying contour map shows the AGB population from Hirschauer et al. (2020). The NIRCам and MIRI fields of view are indicated by dashed boxes.