Bright late-evolved stars and features in their Gaia DR3 BRRP spectra

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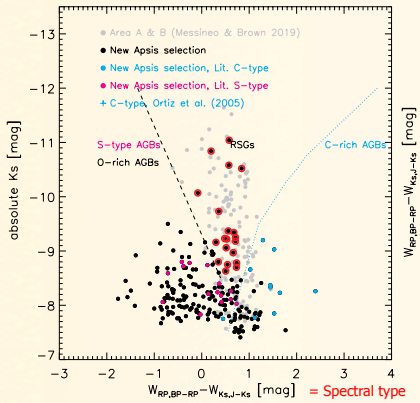
Red supergiants (RSGs) and asymptotic giant branch stars (AGBs) are the brightest stars at infrared wavelengths, easily detectable at a distance of a few megaparsecs. Their complex evolution is dominated by mass loss, and their winds enrich and shape the interstellar medium. Even though the Milky Way is the closest laboratory of resolved stellar populations, dust obscuration and poor knowledge of distances hamper a clear separation of the RSG and AGB populations. Such a separation is crucial to study the history of star formation in the Milky Way and its morphology. Currently, about 500 spectroscopic Galactic RSGs are known (e.g., Messineo & Brown 2019, AJ, 158,20) and about 20,000 AGB stars (Suh 2021 ApJS,256,43).

APIS parameters: Gaia DR3 adds only 20 new RSGs by using the Gaia APIS parameters from BP/RP spectra. Indeed, the pipeline temperatures are usually overestimated for bright cool stars.

Photometric selection tools: Gaia photometry combined with infrared data from 2MASS-WISE enable a good statistical separation of C-rich, O-rich AGBs, and RSGs (Abia et al. 2022 A&A,664,45; Messineo M. 2023 A&A,671,148) and enable us to select (e.g. ~300 photometric candidate RSGs, not included in Messineo & Brown's catalog). See also the recent works on the Gaia selection function of RSGs by Healy et al (2024) which lists 578 high probable RSGs.

Diagram for photometric+plx selection of AGBs and RSGs
Gaia+2MASS data



The extinction free colour $W_{RP,BP-RP}$-$W_{Ks,J-KS}$
is a meter of spectral-types (taken from SIMBAD/VIZIER)

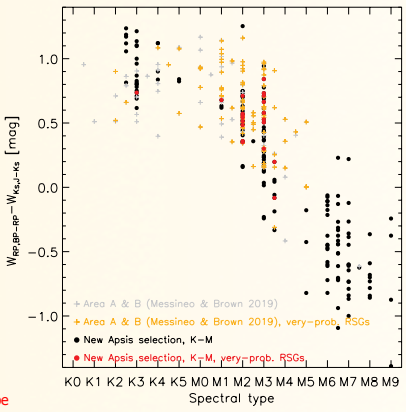
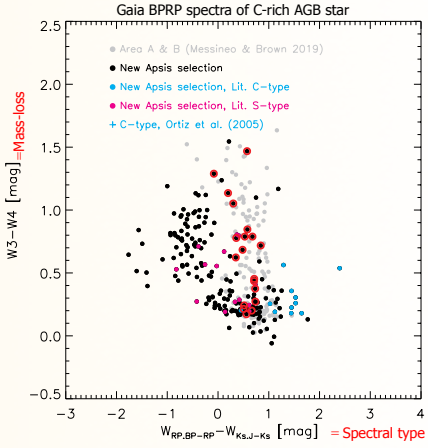


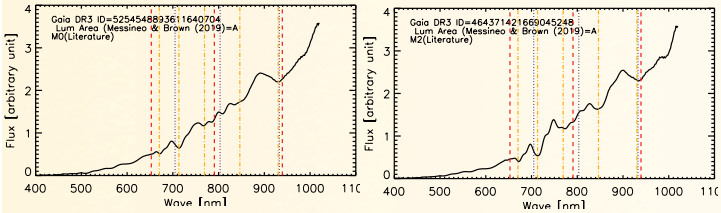
Diagram for photometric selection of AGBs and RSGs
Gaia+WISE data
Gaia BPRP spectra of C-rich AGB star



$W_{RP,BP-RP}$=RP-1.3(BP-RP) ; $W_{Ks,J-Ks}$=Ks −0.686(J − Ks), as defined in Abia et al. (2022).

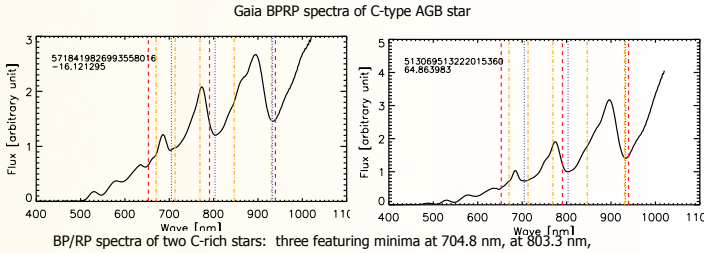
An empirical spectral library of bright late-type stars with BPRP spectra: A library of about 40 BP/RP spectra (including RSGs from K1 to M4, AGBs from M4 to M9, C-rich stars, and S5/5 stars) is created. Infrared estimates of interstellar extinction are made with 2MASS data.
With a minimization matching procedure, spectral types are derived from the BP/RP spectra. They appear to be correct within one type.

Gaia BPRP spectra of red supergiant stars



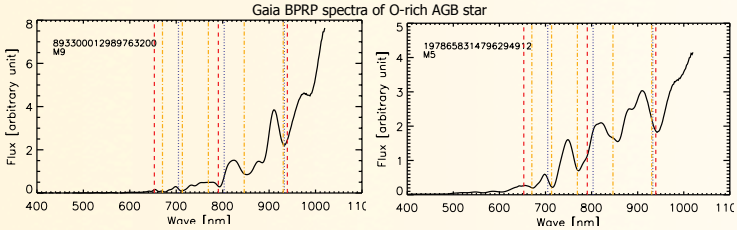
Dashed-dotted orange-vertical lines mark TiO-bands seen in absorption in the spectra of an M0 and an M2 star.

Gaia BPRP spectra of C-type AGB star

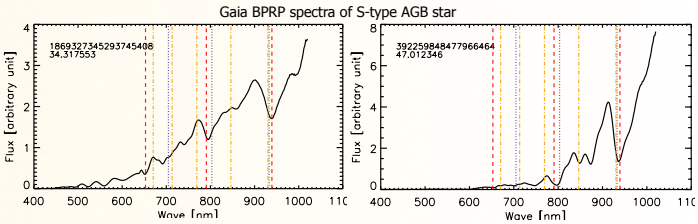


BP/RP spectra of two C-rich stars: three featuring minima at 704.8 nm, at 803.3 nm, and at 932.8 nm are marked with blue-dotted lines. The absorption features are due to strong CN molecular bands.

Gaia BPRP spectra of O-rich AGB star



Gaia BPRP spectra of S-type AGB star



Messineo (2022) shows how a visual inspection of BPRP spectra enable a straightforward separation of O-rich and C-rich stars, and also of late S-type stars. The latter stars have strong absorption of ZrO and LaO molecules. A C-flag is provided in Gaia DR3; This flag erroneously marks a fraction of known RSGs. We suggest a supplementary flag based on a set of EWs (look at the absorption and not at the emission!) that seems to correctly flag C-rich stars and S-type stars (SX/4 and later). Indeed, it is possible to flag late S-type and C-rich stars by measuring three equivalent widths, from 914.00 to 977.39 nm (ew1, ZrO band), from 817.72 to 876.85 nm (ew2, TiO band), and from 780.04 to 809.05 nm (ew3, LaO band) and retaining spectra where
ew1 < 1.5*ew3 and ew1 < 1.9*ew2. Note that ew1, ew2, and ew3 are negative when there is a feature. The second condition excludes very late M-type stars.

The BP/RP spectra of S4 or later S stars present three featuring minima at 652.9 nm (ZrO), at 790.7 nm (LaO), and at 939.3 nm (ZrO). The LaO bands appear in S4-type and are stronger in S5 and later types. ZrO and LaO absorption are marked with Dashed-red lines.

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