Why Galaxies Care About AGB Stars:
A Continuing Challenge through Cosmic Time
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Population of AGB stars in the outer Galaxy

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Abstract. We present preliminary results of a study aimed at identifying and characterizing the Asymptotic Giant Branch (AGB) stars in the outer Galaxy using the color-color diagram (CCD) that combines the *Spitzer Space Telescope* and 2MASS photometry: $K_s - [8.0]$ vs. $K_s - [24]$. Our initial study concentrates on a region in the outer Galactic plane around a galactic longitude l of 105°, where we identified 777 O-rich and 200 C-rich AGB star candidates.

Keywords. stars: AGB and post-AGB, infrared: stars, catalogs

1. Introduction

We are conducting a systematic search for young and evolved stellar objects in the ∼24 deg^2 region in the outer Galaxy dubbed 'l105': $l = (102°, 109°)$ and $b = (-0.2°, 3.2°)$, covered by the "*Spitzer* Mapping of the Outer Galaxy" survey (SMOG, IRAC 3.6–8.0 μm and MIPS 24 μm; PI: Sean Carey). Szczerba *et al.* (2016) identified regions in the $K_s - [8.0]$ vs. $K_s - [24]$ CCD where Young Stellar Objects (YSO) and post-AGB stars are located. They also showed that the location of the hydrodynamical models computed by Steffen *et al.* (1998) reproduce the distribution of the O-rich and C-rich AGB stars from the Magellanic Clouds in this CCD very well. The $K_s - [8.0]$ vs. $K_s - [24]$ CCD allows us to separate C-rich and O-rich AGB stars quite effectively (Matsuura *et al.* 2014). Using this property in combination with hydrodynamical computations of Steffen *et al.* (1998), we selected O- and C-rich AGB star candidates in the l105 region.

2. Selection of the AGB candidates

Figure 1 shows the distribution of *Spitzer* sources in l105 in the $K_s - [8.0]$ vs. $K_s - [24]$ CCD displayed as a Hess diagram. Only sources with highly reliable *Spitzer* 8.0 μm and 24 μm, and 2MASS K_s-band photometry are included (15 311 objects). Most of the objects concentrate around $(K_s - [8.0],\ K_s - [24]) \sim (0,0)$. Black lines and labels indicate regions in the CCD where different types of AGB stars are typically located; see also Fig. 10 in Matsuura *et al.* (2014). The bottom thick solid line and the top dotted line are exactly the same as the corresponding bottom and top lines from Matsuura *et al.* for $x \equiv K_s - [8.0] > 1$. Based on the position of our hydrodynamical tracks in the CCD (red points for C-rich and blue points for O-rich hydrodynamical tracks - see Szczerba *et al.* (2016) for details), we slightly redefined the boundary between O- and C-rich AGB stars, and significantly lowered the top boundary of Matsuura *et al.* for O-rich stars. The equations for these lines, assuming that $y \equiv K_s - [24]$, from bottom to top are: $y - 0.5 = 16/13(x - 1)$; $y - 2 = 14.5/11(x - 1)$; $y - 3.5 = 3.5/2.15(x - 1)$; and $y - 4 = 2(x - 1)$. Our

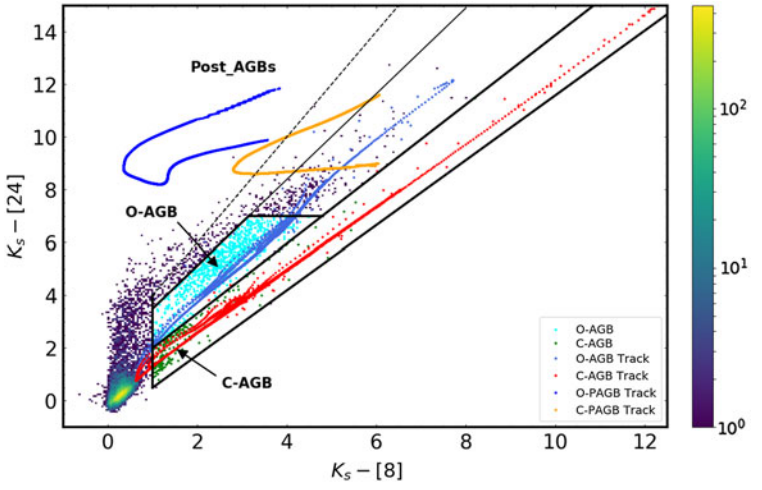

Figure 1. The $K_s - [8.0]$ vs. $K_s - [24]$ CCD showing the distribution of sources from the *Spitzer*/SMOG survey ('*l*105'). The regions occupied primarily by O-rich and C-rich AGB star candidates are delimited by the solid thick lines and labeled. The O-rich and C-rich AGB star candidates are indicated with cyan and green circles, respectively. See text for more details.

analysis excludes sources with $x < 1$ as it is difficult to separate O-rich from C-rich AGB stars in this region in the CCD; this region may also be populated by Red Giant Branch stars characterized by small mass loss rate. As shown by Szczerba *et al.* (2016), O-rich AGB stars with $y > 7$ are mixed with YSOs and post-AGB stars.

The regions within the thick solid lines in the $K_s - [8.0]$ vs. $K_s - [24]$ CCD are selected as areas mostly populated by C-rich and O-rich AGB stars. In total, we selected 200 C-rich and somewhat unexpectedly as much as 777 O-rich AGB star candidates. We used the SIMBAD Astronomical Database - CDS in Strasbourg to search for counterparts of *Spitzer* sources; we used a search radius of $2''$. We found 99 entries for C-rich and only 44 for O-rich AGB star candidates. The probable reason is that selected O-rich candidates are redder and were less frequently observed than C-rich ones. Out of 99 SIMBAD sources matching *Spitzer*/SMOG sources selected based on the $K_s - [8.0]$, $K_s - [24]$ CCD, 38 are classified as 'C*' or 'C*?', while in O-rich sample only three were classified as 'variable' (possibly AGB), whereas eleven as young objects ('Be', 'YSO', or 'WR*'). We plan to further investigate the selected sample.

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