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Infrared-selected post-AGB star candidates in the LMC and SMC

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Samples of post-AGB star candidates in the SMC and LMC have been selected from the *Spitzer Space Telescope* survey catalogues S^3MC and SAGE using the criterion that the star must show a MIR excess. Optical spectra have been obtained for the brighter objects and luminosities and $T_{\rm eff}$ values have been estimated. We examine the optical spectra to find where objects with emission lines indicative of a substantial stellar wind occur in the HR diagram. These winds are possibly capable of shaping planetary nebulae. The variability properties of the candidates are also examined.

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Introduction

Low and intermediate stars (1-7 Msun) terminate their lives either with a `superwind' at the tip of the Asymptotic Giant Branch (AGB) or by loss of the stellar envelope as a result of interaction with a close binary companion. When the mass of the hydrogen-rich envelope has been reduced to ~0.02 Msun, the radius of the central star decreases and, within ~10^2-10^4 years, the temperature increases from ~3×10^3 K to >3×10^4 K. This stage, between the AGB and the Planetary Nebula (PN) phase of a star's life, is known as the Post-AGB (PAGB) phase.

In this study, we show some preliminary results of a search for PAGB stars in the SMC and LMC. The advantage of studying PAGB stars in the SMC and the LMC rather than in the Galaxy is that accurate luminosities can be determined. Luminosity is a good indicator of PAGB star mass and initial stellar mass (e.g. Vassiliadis & Wood 1993,1994). With accurate luminosities, we can therefore study mass-dependent properties such as AGB nucleosynthesis (by examining PAGB star abundances) and PAGB mass loss rate (by the distribution of PAGB stars in the HR-diagram).

Candidate selection

PAGB stars are expected to be of two types. Single stars that have just finished a phase of very high mass loss rate on the AGB will be surrounded by a shell of cool expanding dust (*shell sources*). Binary PAGB stars are expected to have a disk of dust left over from binary interaction (*disk sources*) - see van Winckel (2003) for a review. In both cases, mid-IR dust emission is a signature of PAGB status. Our selection is therefore based on the presence of a mid-IR excess. For the SMC, we used the Spitzer S^{3}MC survey (Bolatto et al. 2007) and required that PAGB star candidates have a K-[8] excess compared to ordinary red giant stars in the (K-[8],K) plane (see bottom panel of Fig. 1). We also required that the candidates not lie on the sequence of dusty AGB stars in the (K-[8],J-K) plane (see top panel of Fig. 1). A similar procedure was used in the LMC using the SAGE survey of Meixner et al. 2006 (see van Aarle et al. 2009 for more details of LMC selection).

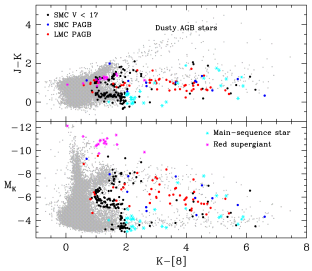

Figure 1. The J-K,K-[8] and MK,K-[8] diagram for SMC point sources in the S3MC catalog (grey points). The black points are selected PAGB star candidates. Those candidates that have spectral types and luminosities that make them likely genuine PAGB stars are show as blue points (and red points for the equivalent LMC objects). Those candidates that turned out to be red supergiants ot main-sequence stars are shown as magenta and cyan stars, respectively (both SMC and LMC objects are shown).

Spectra of PAGB star candidates

Spectra of those PAGB star candidates with V < ~16.5 were obtained with the ANU 2.3m telescope and the DBS spectrograph at Siding Spring Observatory. Sample spectra are shown in Fig. 2. It is clear that the PAGB candidates cover a wide range of spectral types from cool AGB stars to hot main-sequence stars. In addition, planetary nebulae and young stellar objects were found.

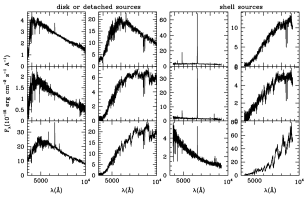

Figure 2. Spectra of a sample of the PAGB candidates observed with the ANU 2.3m telescope.

The HR-diagram

Effective temperatures Teff were assigned to the PAGB candidates from spectral types using the (spectral type,Teff) relation of Hayes (1978) for OBA stars and the relation of van Belle et al. (2009) for FGKM stars. For the latter group, bolometric magnitudes were obtained by integrating under the spectral energy distribution from B to 24 μm, and assuming distance modulii for the LMC and SMC of 18.51 and 18.93, respectively (Keller and Wood 2006). For the hotter stars where the UV flux is important, approximate bolometric luminosities were obtained by applying applying a bolometric correction to the V magnitude.

The resulting HR-diagram is shown in Fig.4. It is clear that there appear to be many genuine PAGB stars between the AGB and the main-sequence.

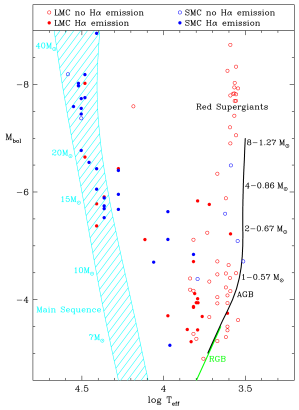

Figure 3. The HR-diagram of PAGB candidates. SMC and LMC objects are identified as are those objects with Hα emission. The masses on the AGB are the initial and final (i.e. PAGB) masses that terminate at these luminosities.

Variability

For those objects with F, G or K spectral types, light curves were obtained from the MACHO data base. A wide variety of light curves were obtained as shown in Fig. 4.

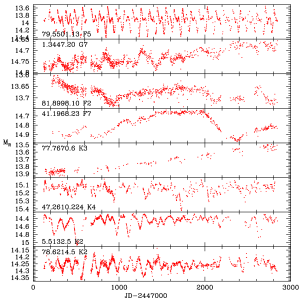

Figure 4. MACHO light curves of PAGB candidates.

Some of the candidates turned out to be previously known RV Tauri stars and Population II Cepheids (e.g. 79.5501.13). Some stars show long-term brightening suggesting a very rapid evolution, as expected for PAGB stars (e.g. 1.3447.20, 77.7670.6). Others show RCB type variability (episodic dimming and recovery e.g. 41.1968.23) or sequence-D behaviour with long secondary periods (Nicholls et al. 2009 e.g. 47.2610.224) or semi-regular variability typical of AGB stars, although they appear to be hotter than AGB stars (e.g. 5.5132.5, 78.6214.5).

Summary and conclusions

We have shown that selecting PAGB star candidates on the basis of a mid-IR excess leads to identification of genuine post-AGB stars. As a result of the success of this experiment targeting the optically bright stars for spectral follow-up, we now plan to obtain spectra of a much larger sample of PAGB star candidates in the SMC and LMC down to much fainter magnitudes (V ~ 19) using AAOmega on the AAT.

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