**Mass Loss, Pulsation and Atmospheric Mixing in Intermediate Mass Stars**

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**Background:**
Towards the end of their evolutionary lifetimes, low- to intermediate- mass (1-8 $M_{\odot}$) stars undergo a series of events which have significant implications for the dust and gas content of their parent galaxies. As they pass through the asymptotic giant branch (AGB) their surface abundances can change as the heavy elements produced by late-stage nucleosynthesis can be mixed to the surface; they might pulsate and will lose mass to the interstellar medium. These are high luminosity stars, which become increasingly cool as they evolve. There have been significant advances in recent years in the theoretical understanding of the AGB phase of evolution, but there is still a great need for observational evidence to help pin down many aspects of the theory.

The mixing of heavy elements into the atmosphere accompanies thermal pulses in what is referred to as the third dredge-up phase (3DUP). One of the elements involved is technetium (Tc), which, since its longest-lived isotope, $Tc^{99}$, has a half-life of $2x10^5$ years, much shorter than the star's lifetime on the AGB, is a guarantee that 3DUP has occurred. In intermediate mass AGB stars, the phenomenon of hot-bottom burning may occur, resulting in the transport of lithium (Li) to the surface; the theory is still not well developed, so the spectroscopic detection of Li in stars of a range of masses would be a useful contribution to clarifying the structural development of these stars.

While proceeding along the AGB, stars begin to pulsate, first as low-amplitude semi-regular variables and eventually as large-amplitude Mira variables. Pulsation and convection drive mass loss, although the details of these processes remain unclear. Mass in the form of both dust and gas is lost. AGB stars are arguably the most important contributors of dust to the interstellar medium. The dust mass-loss rate can be measured via near- and mid-infrared photometry. The mass lost as gas exceeds that lost as dust by about 200 times (depending on metallicity), and can be measured from the strength of rotational lines of CO in the mm-wave range. It resides in a circumstellar envelope that may have a diameter of several thousand stellar radii; for one star the chemical composition of its envelope has been determined from its effect on the spectrum of a background star whose light shines through the envelope. This is extremely difficult work, but would be worth attempting with the Southern African Large Telescope (SALT) if other suitable candidates could be found and could be a mini-project in advance of the main study described below.

**Primary PhD Investigation:** The student is expected to start with a list of objects for which CO measurements have been, or will be, obtained from mm-wave telescopes, and identify
[1] which have mid-infrared observations from which mass-loss rates can be derived.
[2] for which of these stars it will be possible to obtain spectra around the region of the Tc line ($\lambda$4262) and/or the Li line ($\lambda$6708) with the high resolution spectrograph (HRS) on SALT.

The student will apply for time on SALT and analyse the resulting spectra as their main project. Having obtained these data the student should be equipped to contribute to the understanding of the relationships between evolutionary mixing, pulsation and mass loss in the AGB.