

# The Post-AGB cores in 'non-variable' OH/IR stars

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Almost since their discovery more than 20 years ago 'non-variable OH/IR stars' were suspected to be stars beginning their post-AGB phase. Due to the extreme optical thickness of their circumstellar shells not much information except far-infrared fluxes and maser observations were available. Using the new Spitzer/GLIMPSE and the 2MASS surveys the faint near-infrared counterparts can now be identified beyond doubt. These counterparts are the central stars (the Post-AGB core) emerging from the steadily diluting shells. These stars will develop on short timescales into Proto-Planetary Nebulae with prominent double-peaked spectral energy distributions.

## Introduction

The observed diversity in morphologies of Planetary Nebulae seemingly is determined at the end of AGB evolution when the mode of mass loss changes on short timescales (Balick & Frank 2002). It is commonly assumed that the end of AGB evolution is reached when the star has lost most of its mass and only a tiny amount ( $\sim 10^{-3} M_{\odot}$ ) of the envelope above the degenerate C-O core remains. At this moment, the pulsation thought to drive the heavy mass loss on the AGB (Willson 2002), stops and the mass loss rate decreases in a couple of centuries from  $>10^{-5} M_{\odot}/\text{yr}$  to  $\sim 10^{-8} M_{\odot}/\text{yr}$ . This departure from the AGB is accompanied by a drastic change of the overall spectral energy distribution (SED): An heavy obscured OH/IR star, which is optically invisible on the AGB, converts into an optically visible post-AGB star with a strong infrared excess (Figure 1).

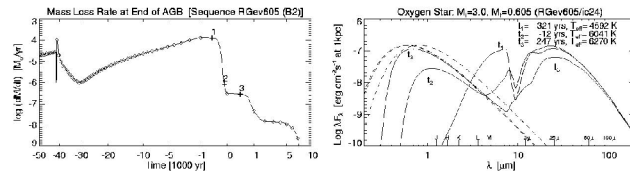


Figure 1: Development of the mass loss rate after the last thermal pulse (left) and development of a double-peaked spectral energy distribution (right) in response to the drop of the mass loss rate between time stamps  $t_1$  and  $t_2$  (from Steffen et al. 1998)

OH/IR stars, which have stopped pulsating ('non-variable OH/IR stars'), are considered to be in this transition phase (Van der Veen, Habing & Geballe 1989, Engels 2002). They may already have detached shells, and their  $H_2O$  masers already witness the changes of the mass loss process, while the OH masers located farther out are still undisturbed. The number of 'non-variable OH/IR stars' found by the monitoring program of Herman & Habing (1985) is however surprisingly high. Out of 45 stars monitored 13 (28%) did not show any variability, although they are as strongly obscured as the variable OH/IR stars. A first order guess implies then that the time a star spends as a 'non-variable OH/IR star' is about one third of the lifetime as regular OH/IR star, and assuming that the transition process is a few hundred years yields an uncomfortably short lifetime for regular OH/IR stars of only  $\sim 1000$  years. This would mean that OH masers appear only after the very last thermal pulse.

I readdress here the nature of the 'non-variable OH/IR stars' using a new analysis of the properties of their parent sample on the base of near-infrared photometry from GLIMPSE and 2MASS.

## The parent sample

The parent sample is a compilation of several blind 1612 MHz OH maser surveys (Baud et al. 1981) along the galactic plane with a completeness limit of  $\sim 5$  Jy. The sample contains  $N=114$  OH/IR stars, of which Herman & Habing (1985) monitored the  $N=45$  strongest. No differences in the distance distributions for variable/non-variable OH/IR stars are evident (Figure 2).

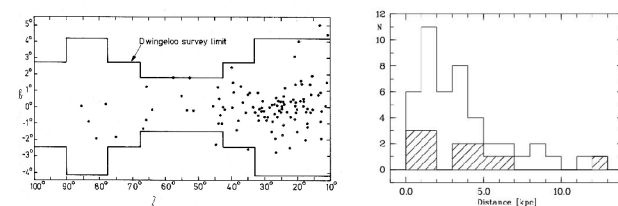


Figure 2: Left: Distribution of OH/IR stars from the compilation of Baud et al. (1981). Four stars with  $l > 100^\circ$  were omitted. Right: Distances for variable and non-variable (hatched) OH/IR stars (from Herman & Habing 1985).

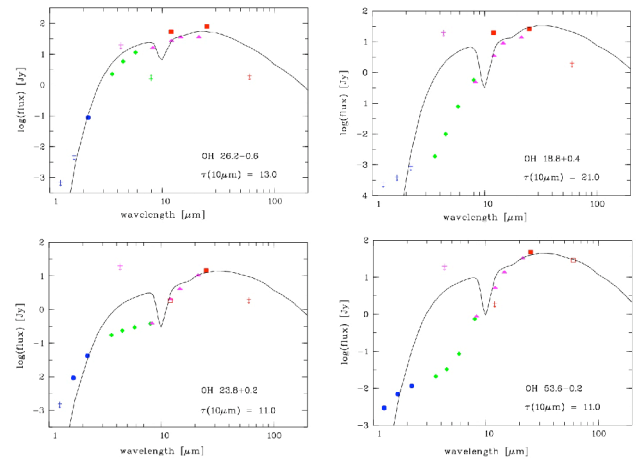


Figure 3: Four types of spectral energy distributions: OH 26.2-0.6 (upper left) is a classical large-amplitude variable OH/IR stars, showing no near infrared excess. The other three objects show excesses with different strength. Two of them (OH 18.8+0.4, OH 53.6-0.2) are 'non-variable OH/IR stars', for the third the variability status is unknown. Theoretical models adequate to fit the SEDs of regular OH/IR stars fail for the transition objects.

Symbols: 2MASS  $\bullet$ , GLIMPSE  $\blacklozenge$ , MSX  $\blacktriangle$ , IRAS  $\blacksquare$

## 1 - 60 $\mu\text{m}$ spectral energy distributions

For all OH/IR stars in the sample, except three, IRAS and/or MSX counterparts were identified. At the positions of the MSX sources near-infrared counterparts were searched for in the ground-based 2MASS infrared survey (J, H, and K filters) and in the space-based Spitzer/GLIMPSE survey at 3.6, 4.5, 5.8 and 8.0  $\mu\text{m}$ . The counterparts for regular variable OH/IR stars are usually very red, however among the 'non-variable OH/IR stars' several rather blue counterparts were found (Figure 3). Usually, without the GLIMPSE data it was difficult to verify the blue counterparts detected, because of the high probability of chance coincidences with field stars in the galactic plane. Of 10 'non-variable OH/IR stars' having GLIMPSE photometry 6 show the near infrared excess. The remaining 3 outside the GLIMPSE area all have blue 2MASS counterparts. The presence of a near-infrared excess in 'non-variable OH/IR stars' as a general phenomenon is now beyond doubt.

## Discussion

The near-infrared excess is due to the dilution of the circumstellar shell after the end of the strong AGB mass loss. These stars will develop into the better known optical visible post-AGB stars with strong far-infrared excesses. Currently modelling of the post-AGB SEDs are attempted using DUSTY. First attempts assuming an abrupt drop of the mass loss rates however failed to reproduce the observed SEDs.

The strong OH masers allow to pinpoint stars in this short evolutionary throughout the Galaxy. Their rather high frequency among OH/IR stars remain however a puzzle, if the short transition times predicted by theory are considered.

## References:

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