Cosmic Masers: Proper Motion toward the Next-Generation Large Projects
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The loss of OH maser emission in the early stage of Post-AGB evolution

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Abstract. Based on the results of an on-going monitoring program of 1612 MHz OH masers in OH/IR stars, we determined a lifetime encompassing late AGB and early post-AGB evolution of at least 4500 years. Fading of the OH masers observed with the Nançay Radio Telescope is detected in several post-AGB OH/IR stars on timescales of decades, while AllWISE/NEOWISE light curves taken almost in parallel show diverse behaviours.

Keywords. masers, infrared: stars, stars: AGB and post-AGB, star: evolution,

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1. Introduction

The transition of ∼2-8 $M_\odot$ stars from the Asymptotic Giant Branch (AGB) to the post-AGB stage is accompanied by strong mass loss leading to the formation of optically-thick circumstellar shells. Variable OH/IR stars with high mass-loss rates ($\geq 10^{-6}\,M_\odot\,yr^{-1}$) become obscured at visual light and, for the most extreme cases, also in the near-infrared (NIR: 1–5μm). Their 1612 MHz OH maser light curves on the AGB show large amplitude variations with periods up to 2500 days. Other OH/IR stars with non-periodic small amplitudes variations are characteristic of post-AGB evolution. After that most of their mass is lost during the AGB phase, the mass-loss rates drop on short timescales of a few thousand years from late AGB values of 10^{-5}–10^{-4} to post-AGB values of 10^{-7}–$10^{-8}\,M_\odot\,yr^{-1}$ (Miller-Bertolami 2016). Because of the short time scales and the obscuration of the stars, the details of the transition process from the AGB to the post-AGB phase are not well constrained. There is however growing evidence accumulating that following variations of the IR emission (Kamizuka *et al.* 2020), and of the OH masers (Wolak *et al.* 2014) on timescales of decades allows to study aspects of this transition process in real time. From an ongoing 1612-MHz OH-maser monitoring program we present here post-AGB OH/IR stars with fading OH maser emission.

2. Post-AGB OH/IR stars with fading OH masers

The sample monitored comprises 114 stars located along the Galactic plane at $10 < l < 150°$, and $|b| < 4°$. The majority of the OH/IR stars are periodically pulsating AGB stars (N=78, 68%), while 31 stars (27%) show only small-amplitude irregular variations (Engels *et al.* 2019)†. For the latter we extracted infrared photometry from the ALLWISE Multiepoch Photometry Catalog (Wright *et al.* 2010) and (Cutri *et al.* 2013)

† Updates available on the project web page www.hs.uni-hamburg.de/nrt-monitoring

Table 1. Post-AGB OH/IR stars with fading OH masers. T_{end} is the predicted year at which the peak flux density should drop below 100 mJy. ΔW2 is the systematic IR brightness change between 2009 and 2021 derived from NEOWISE data.

Name	$\mathbf{T}_{end}$ [yr]	**ΔW2 [mag/yr]**	**Name**	$\mathbf{T}_{end}$ **[yr]**	**ΔW2 [mag/yr]**
OH 12.8−0.9	2031	−0.06	OH 31.0+0.0	2030	+0.03
OH 17.7−2.0	2035	+0.04	OH 37.1−0.8	2043	−0.02
OH 18.5+1.4	∼2100	< 0.01			

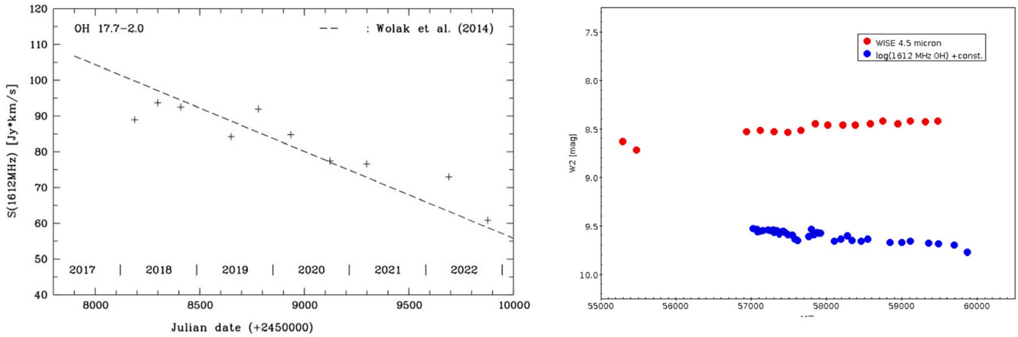

Figure 1. *Left:* 2018-2022 light curve of 1612-MHz OH-maser emission of OH 17.7−2.0. Superimposed is the predicted light curve by Wolak *et al.* (2014). *Right:* 2015–2022 1612-MHz OH maser light curve of OH 37.1 − 0.8 in logarithmic units (blue) and 2009–2021 WISE 4.5μm light curve (red). The OH maser data is shifted by an arbitrary constant.

and the 2022 NEOWISE-R Single Exposure (L1b) source table (Mainzer *et al.* 2014) to obtain light curves over the years 2009–2021. We averaged the photometry in 10 day intervals and made linear fits to the data restricting on the NEOWISE data.

Following Engels & Jiménez-Esteban (2007), we made a new estimate of the OH maser lifetime based on the re-detection of all masers in 2022. We obtained statistically a lower limit for the lifetime of > 4300 years (1σ) and a post-AGB minimum lifetime of > 1700 years (Ullrich *et al.* in preparation). Among the post-AGB OH/IR stars we identified 5 stars (namely, OH 12.8−0.9, OH 17.7−2.0, OH 18.5+1.4, OH 31.0+0.0, and OH 37.1−0.8) with continuous decline of the integrated 1612-MHz OH-maser emission. The predicted drop to peak flux densities <100 mJy is expected to occur within the next 80 years (Table 1). The most convincing case is OH 17.7−2.0. The fading was discovered by Wolak *et al.* (2014) who predicted its disappearance by 2030. Our recent observations 2018–2022 confirm the masers ongoing decline (Fig. 1, left panel).

We searched in the AllWISE/NEOWISE photometry for increasing infrared brightness evolving in parallel, following the findings of Kamizuka *et al.* (2020) at 2.2μm. We found mixed results for the systematic brightness variations in the WISE W1 and W2 bands. For two objects brightening and for two objects dimming was seen (Table 1). Also, five out of six post-AGB OH/IR stars of the sample of Kamizuka *et al.* (2020) showing IR brightening at 2.2μm, show no long-term variations of the OH maser brightness in our monitoring program. An exception is OH 37.1 − 0.8 for which the light curves are shown in Fig. 1 (right panel).

Our results do not show a clear correlation between the fading OH and long-term infrared brightness variations. However, the long-term variations show that stellar evolution in the AGB to post-AGB transition phase can be observed in real time.

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