Cosmic Masers - from OH to H_0
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1612 MHz OH maser monitoring with the Nançay Radio Telescope

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Abstract. 20 OH/IR stars are monitored in the 1612 MHz OH maser line with the Nançay Radio Telescope. The program started in 2008 with monthly observations of the full sample and will last at least until end of 2012. The aim is the determination of the linear diameter of the circumstellar shell using the phase lag between the light curves of the varying OH maser lines. To use them for distance determinations, angular diameters are obtained by interferometric measurements while the stars pass the maximum of their OH maser flux density variations. The periods of the OH/IR stars monitored are between 425 and >2000 days.

Keywords. masers, stars: AGB and post-AGB, stars: late-type

1. Phase-lag distances

OH/IR stars have optically thick circumstellar dust and gas envelopes and were discovered first by their intense OH maser emission. They pulsate similarly to Miras, but with much longer periods (>2 years). The general understanding is that OH/IR stars have more massive main-sequence progenitors than Mira variables. However, because of the uncertain distances of OH/IR stars, the evidence for mass segregation between Mira and OH/IR stars is concluded from indirect arguments (Habing 1996, Chen *et al.* 2001).

A promising technique to determine distances to OH/IR stars is the use of phase-lags between the two varying OH maser peaks originating from the front and back sides of the shell. These lags yield linear diameters and combined with angular diameters, obtained from interferometric observations, distances can be derived. This technique was explored in the 1980ies by Herman & Habing (1985) finding that the majority of their sample of OH/IR stars has distances between 2 and 10 kpc. The accuracy of these distances

Table 1. Periods and amplitudes determined after four years of observations (≈ 1500 days) of the stars observed. P is the period in days and Amp. is the relative amplitude defined as amplitude/mean flux density.

Object	P	Amp.	Object	P	Amp.	Object	P	Amp.
IRAS 01037+1219	650	0.48	OH 20.7+0.1	1720	0.49	OH 55.0+0.7	1270	0.44
OH 127.8+0.0	1590	0.51	OH 26.5+0.6	1589	0.44	IRAS 20234−1357	425	0.37
OH 138.0+7.2	1580	0.20	OH 30.1−0.7	2000	0.38	OH 75.3−1.8	1652	0.45
OH 141.7+3.5	3500	0.42	OH 32.0−0.5	1410	0.40	OH 83.4−0.9	1497	0.47
IRC +50137	635	0.61	OH 32.8−0.3	1690	0.60	IRAS 21554+6204	1400	0.43
IRAS 05131+4530	1050	0.49	OH 39.7+1.5	1260	0.40	OH 104.9+2.4	1750	0.50
OH 16.1−0.2	2000	0.24	OH 44.8−2.3	534	0.40			

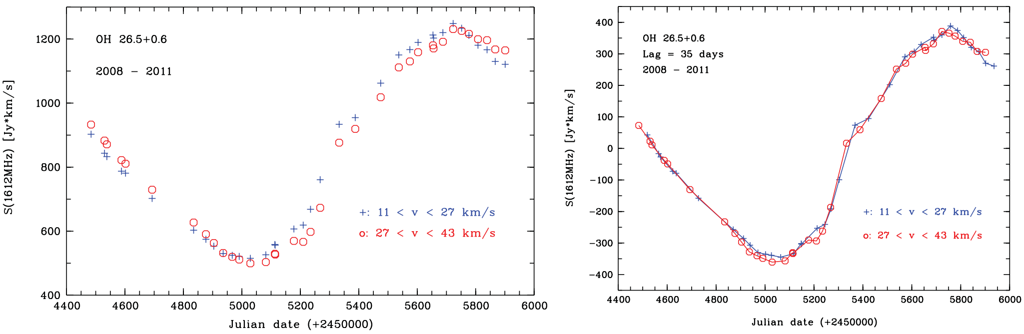

Figure 1. *Left:* Lightcurves of the integrated maser flux of the blue and the red maser peak of OH 26.5+0.6 between 2008 and 2011. The fluxes of the red peak were scaled to match the blue peak in mean flux and amplitude. The red lightcurve (o) lags behind the blue lightcurve (+). The period of the star is 4.35 years. *Right:* Result of the correlation of the normalized lightcurves. The difference between the lightcurves is minimized for $\tau_0 = 35^{+5}_{-8}$ days, where the error interval is defined by a 10% degradation of the fit.

is however not well determined. Van Langevelde *et al.* (1990) re-determined the phase-lags and hence linear diameters and revised their values to a much greater extent, than expected from the errors quoted.

2. Observations and first results

We therefore decided to remeasure with the Nançay Radio Telescope the phase-lags for a number of sources and to apply this technique to new sources with bright OH masers. The list of sources is given in Table 1. The observations are made every month with the Low-Frequency receiver. The digital autocorrelator is split into two banks with a bandwidth of 0.78125 MHz centered on 1612.231 MHz to observe both linear polarizations simultaneously. The velocity resolution is 0.035 km/s. Typical integration times are 8 minutes on source, which yield a noise level of ≈ 0.1 Jy and an S/N > 100.

OH 26.5+0.6 has the strongest maser in the sample and is used to experiment with different strategies to determine the phase-lag. Fig. 1 shows the phase-lag determination using integral fluxes for the two peaks. This gives the best signal-to-noise ratio, but averages the differing phase-lags arising from different velocity intervals. The lightcurves of the two peaks were normalized, after that the data was edited and smoothed to get rid of scatter. After scaling the red peak in amplitude and shifting it along the time-axis, the lightcurves were correlated. A phase-lag of $\tau_0 = 35^{+5}_{-8}$ days was determined by minimizing the differences of the fluxes (Fig. 1).

This phase-lag is in excellent agreement with the result of van Langevelde *et al.* (1990), who obtained $\tau_0 = 37 \pm 7$ days. It confirms the consistency of the lightcurve analysis methods and shows that no major changes in the structure of the OH masing shell of this star occurred during the last 30 years. For most of our sample at least one period will be covered end of 2012 and phase-lag distances of the sample will be available as soon as the interferometry observations are completed.

References

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