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Pulsation Properties of a Sample of Mira and OH/IR Stars

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Abstract. Well-sampled light curves have been obtained for 1612-MHz hydroxyl masers in Mira and OH/IR stars monitored with the Hartebeesthoek radio telescope. Pulsation modes are investigated via the ratios of the observed periods in the maser variations.

1. Introduction

The ranges of stellar masses and photospheric radii possible in Miras and OH/IR stars are such that pulsation could be occurring in the fundamental mode or the first or second overtones.

Stellar radii and masses are free parameters in theoretical pulsation models, but accurate distances are needed to derive the radii and masses of actual stars. The 1612 MHz hydroxyl masers in OH/IR stars provide a method for determining individual stellar distances. The maser intensity follows the luminosity changes of the central star, but with a phase lag across the maser profile owing to the light travel time from the back to the front of the masing shell. Measurement of the phase lag gives the linear size of the shell. The ratio of the linear size to the angular size, determined interferometrically, then gives the distance to the star (van Langevelde et al. 1990).

A programme to determine distances to a set of Miras and OH/IRs using this method was initiated in 1985. Fortnightly or weekly observations with the aim of measuring the phase lag across the OH shell are carried out with the 26-m Hartebeesthoek telescope. The MERLIN array is used to measure the angular sizes of the OH shells.

2. Pulsation mode determination via period ratios

The OH monitoring data can also be used in an alternative method for determining the pulsation modes which does not require the stellar distances to be found. The ratio of the observed periods P of the primary and first overtone are compared to the ratios of the fundamental P_0 and first overtone P_1 and the first and second overtone P_2 predicted by models. The theoretical ratios form a set of curves as a function of period for each modelled mass (Ostlie & Cox 1986).

The variations of the masers from eight OH/IR stars in our sample were Fourier transformed to enable significant periodicities to be identified in the time series (Scargle 1982). No overtones were found in the power spectra of IK Tau

($P = 470$ days), IRC–20197 ($P = 640$ days) and OH358.2+0.5 ($P = 1230$ days). The periods and period ratios of the other stars are summarised in Table 1.

Table 1. Secondary periods P_{Sn} with significance $\geq 2\sigma$ present in the power spectra of the OH maser variations, and their ratios to the primary period P_P.

star	P_P days	P_{S1} days	P_{S2} days	P_P / P_{S1}	P_P / P_{S2}
OH338.1+6.4	645	400	–	1.61	–
WX Psc	650	860	516	0.76	1.26
OH1.3+1.0	945	545	–	1.73	–
OH1.1–0.8	1310	720	540	1.82	2.43
OH357.3–1.3	2000	1030	–	1.94	–

For OH338.1+6.4 the sidelobe levels of the window function suggest that the apparent secondary period is a sampling artifact. WX Psc has the longest span of data and is the only object showing a significant period longer than the primary but distinguishable from long term trends.

The observed ratios P_P / P_{S1} are smaller than predicted by the Ostlie & Cox (1986) models if P_P is identified with P_0. The predicted P_1 / P_2 is of the order of 75 per cent of P_0 / P_1, and is more consistent with the observed period ratios. Clearly this is dependent on the applicability of the models. There is a general trend for P_0 / P_1 to increase with increasing period, in agreement with the model predictions. The period ratio for OH357.3–1.3 comes closest to the predicted P_0 / P_1 ratio for fundamental mode pulsation. Pulsation in this mode would imply that the stellar mass is at least 5 $M_\odot$ and its radius is $\geq$1250 $R_\odot$. A switch from P_1 to P_0 as the star expands would be consistent with Wood's (1974) suggestion.

Fourier transforms of the OH maser luminosity variations show significant periods other than the primary in five out of eight cases. The period ratios are more consistent with the primary pulsation mode being the first overtone rather than the fundamental, with the possible exception of the 2000-day period OH357.3–1.3.

References

Ostlie, D. A., & Cox, A. N. 1986, ApJ, 311, 864

Scargle, J. D. 1982, ApJ, 263, 835

van Langevelde, H. J., van der Heiden, R., & van Schooneveld, C. 1990, A&A, 239, 193

Wood, P. R. 1974, ApJ, 190, 609

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