Astrophysical Masers and their Environments
Proceedings IAU Symposium No. 242, 2007
J.M. Chapman & W.A. Baan, eds.

doi:10.1017/S174392130701321X

Variability of masers in circumstellar shells on timescales of decades

D. Engels[1], A. Winnberg[2], J. Brand[3] and F. Jiménez-Esteban[4]

[1]Hamburger Sternwarte, Gojenbergsweg 112, D–21029 Hamburg, Germany
email: dengels@hs.uni-hamburg.de

[2]Onsala Rymdobservatorium, Observatorievägen, S–43992 Onsala,at 1612 MHz Sweden

[3]INAF – Istituto di Radioastronomia, Via Gobetti 101, I–40129 Bologna, Italy

[4]Observatorio Astronomico Nacional, Apartado 112, E–28803 Alcala de Henares, Spain

Abstract. Based on a 15–20 year long monitoring program of H_2O masers and new observations of OH masers discovered 35 years ago, we studied the variability of maser emission in AGB stars over timescales of decades. The H_2O maser features in the semi-regular variable stars RX Boo and SV Peg, and of the Mira stars U Her and R Cas, showed strong fluctuations superposed in case of the Mira stars on regular variations due to the pulsation of the stars. The spatial distribution of the emission regions in RX Boo and U Her showed deviations from spherical symmetry, which remained unchanged over >10 years. We conclude that the spatial asymmetry is determined by the underlying asymmetry of the mass loss process. There is no evidence that mass loss rates or the wind geometry in these stars have varied over the last 20 years.
In 2005 we re-detected at 1612 MHz the 114 OH/IR stars discovered before 1978, implying an OH maser lifetime of >2800 years (1σ).

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

Maser emission from OH, H_2O and SiO molecules is frequently observed for stars on the Asymptotic Giant Branch (AGB). Interestingly, a large fraction of oxygen-rich AGB stars do not exhibit detectable masers or emit only in one or two of these molecules. The reasons for the absence of masers among apparently similar stars (e.g. similar distances, luminosities, mass loss rates) is not known. Recently the idea that the (non-)detection of masers is a temporary effect has gained support by the disappearance of five 1612 MHz OH masers, when re-observed 12 years after their first detection (Lewis 2002). Lewis concluded that the mean lifetime of 1612 OH emission is a mere 100–400 years, implying that masers in general might be short-lived phenomena. Long-term monitoring programs and new observations of known masers should then uncover more stars which do no longer have masers. This question can be addressed with our systematic study of the variability of H_2O maser properties of several AGB stars. We also made a simple test to determine the lower limit of the lifetime of 1612 OH masers in OH/IR stars.

The 22 GHz H_2O maser lines of the semi-regular variable RX Boo were observed with the Effelsberg and Medicina radiotelescopes between 1987 and 2007, complemented by five maps obtained 1990–1995 with the VLA (Winnberg *et al.* 2007). The maser was strongly variable with peak flux densities varying between a few Jy and >1000 Jy (Fig. 1a). In each of the VLA maps we identified 10–15 unresolved maser spots. Spots common in consecutive maps were used to align the maps taken in 1990–92 (Fig. 1b). Most of the emission comes from an incomplete ring of inner radius 91 mas (15 AU), showing a velocity gradient in a NW–SE direction. We modelled the maser region as a shell with thickness 14–35 AU ($\approx 4 - 12 R_\star$), which is only partially complete. The wind crossing time is 18 years. Combining our 5 maps with one obtained in 1985 (Bowers *et al.* 1993)

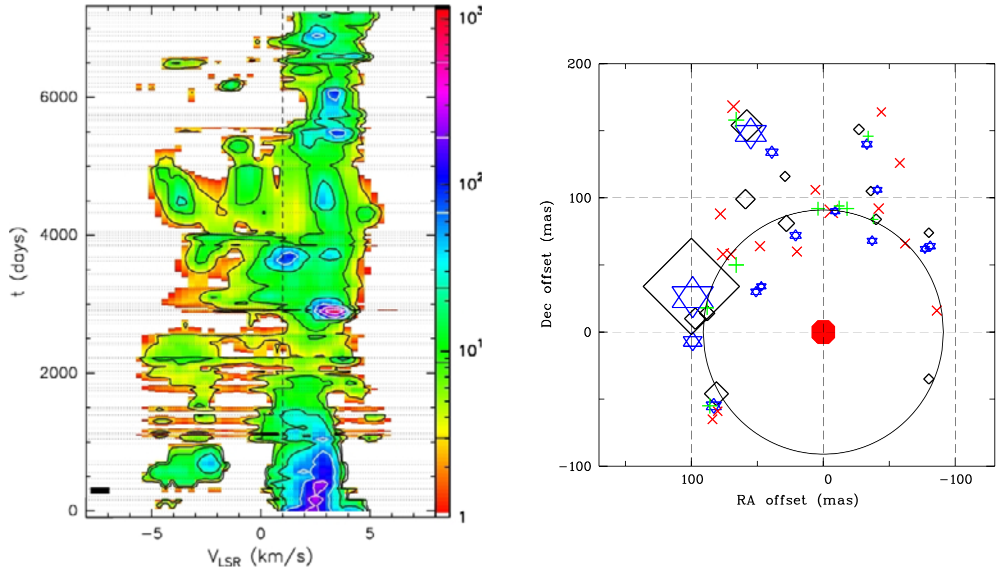

Figure 1. *Left:* Flux density variations of the H_2O masers of RX Boo from single-dish observations. The time axis starts on 1987 March 30. The dashed horizontal lines mark the actual observations and flux densities in between were interpolated in steps of 4 days. The dashed vertical line marks the stellar systemic velocity. *Right:* All maser components identified from four VLA maps taken between 1990 and 1992. The component sizes are scaled according to their strengths and the observing epochs are marked by different symbols and colors. The assumed location of the star is shown at the origin.

we find that structure and velocity gradient remained stable over at least 11 years, while the maser line profiles varied strongly. This implies that the spatial distribution observed at a given epoch is not accidental due to the random process of maser cloud formation, but that the mass loss process in RX Boo itself is not spherically symmetric. The results for RX Boo are in agreement with the properties of the H_2O maser variability that we have observed in the Mira stars U Her (Engels *et al.* 1999) and R Cas (Brand *et al.* 2002).

To assess the stability of the 1612 OH maser emission in OH/IR stars we re-observed in 2005 at Effelsberg a sample of 116 OH masers discovered before 1978 (Baud *et al.* 1981). We rediscovered all OH/IR stars (N=114) in the sample (Engels & Jiménez-Esteban 2007). Probabilities that all masers are re-detected for lifetimes T are: 1% for T= 700 years, 10% for T=1400 years, and 32% for T=2800 years. The short lifetimes found by Lewis (2002) are therefore excluded for this sample. However, the stability of the OH masers depends probably on gas density, and hence on mass loss rates. Lewis found ‘dead OH/IR stars’ only among the blue objects of his sample, which have a much lower mass loss rate than the typical star of our sample. The two results may therefore not be contradictory.

References

Baud, B., Habing, H. J., Matthews, H. E., & Winnberg, A. 1981, *A&AS* 95, 156
Bowers, P. F., Claussen, M. J. & Johnston, K. J. 1993, *AJ* 105, 284
Brand, J., Baldacci, L. & Engels, D. 2002 in V. Migenes, M. Reid (eds.), IAU Symp. 206, p. 202
Engels, D., *et al.* 1999 in T. Le Bertre *et al.* (eds.), IAU Symp. 191, p. 373
Engels, D. & Jiménez-Esteban, F. 2007, *A&A* submitted
Lewis, B. M. 2002, *ApJ* 576, 445
Winnberg, A., Engels, D., Brand, J., *et al.* 2007, in preparation

https://doi.org/10.1017/S174392130701321X Published online by Cambridge University Press