Cosmic Masers - from OH to H_0
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SHOOTING STARS
Masers from red giants

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Abstract. SiO maser emission probes the region close to the stellar surface where the wind is formed and is observed to better constrain the physical conditions in this region. We have started a long-term project where high-excitation ^{28}SiO maser lines (i.e., J = 5-4, v = 1 and 2) are observed in a large sample of southern AGB stars. The primary goals are to put constraints on the physical conditions in the extended atmospheres, and to achieve a better understanding of the maser excitation process. Since the maser emission is strong and often highly linearly polarized, the detected sources could also complement the polarization calibrator catalogue for ALMA. Preliminary results show a high detection rate and that in approximately 20% of the sources, the v = 2 transition emits stronger than the v = 1 transition. We interpret this as possibly indicative of a hot dust shell very close to the stars.

Keywords. masers, polarization, catalogs, stars: AGB and post-AGB, stars: mass loss

1. Maser excitation and physical conditions in evolved stars

SiO maser emission will trace the physical conditions just above the stellar surface where the mass loss is initiated. The pumping of the masers can be either collisional or radiative and the presence and temperature distribution of the dust can have a strong effect on the excitation of the molecules through radiative excitation by the dust emission radiation field (Gray *et al.* 2009). Theory predicts that masers from separate vibrational levels will be emitted at different radii from the evolved star (e.g., Elitzur *et al.* 1983, Langer & Watson 1984, Bujarrabal 1994a, Bujarrabal 1994b, Doel *et al.* 1995) and our preliminary analysis of the available data already hints at very interesting results. Besides a high detection rate, just under 20% of the sources exhibit stronger emission in the $v = 2$ transition. Recent modelling work (Gray *et al.* 2009), indicates that for the much stronger

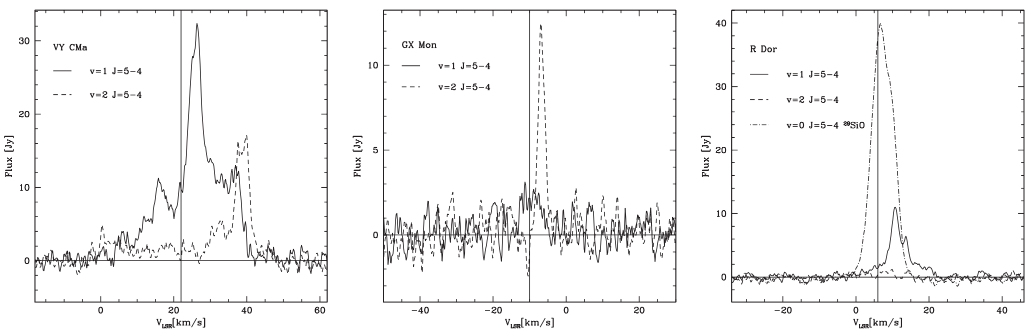

Figure 1. Spectra of some of the high-excitation masers detected with APEX.

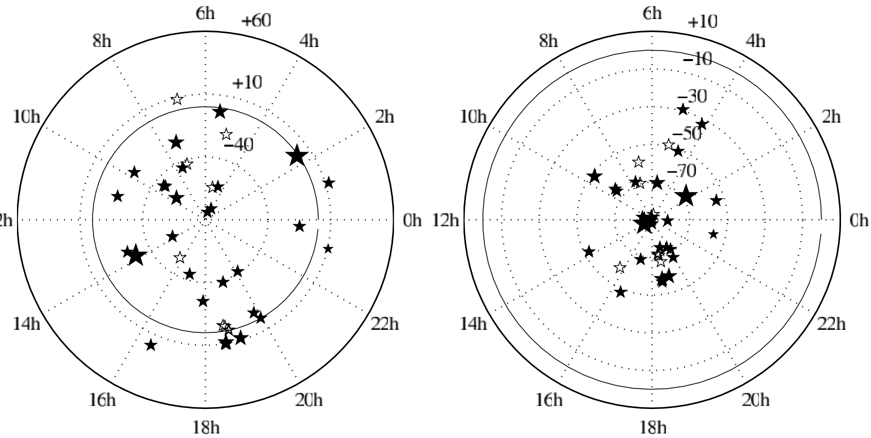

Figure 2. *Left:* The source distribution in RA and Dec. *Right:* The source distribution in RA and maximum elevation at the ALMA site. The strength of the $v = 1$ maser emission is indicated by the size of the star; the smallest correspond to ~ 1 Jy, the medium size correspond to ~ 10 Jy, and the largest correspond to ~ 100 Jy. Open stars mark non-detections.

amplification in the $v = 2$ transition, radiative effects due to a hot dust shell of small inner radius, are required. Further modelling of this effect is ongoing.

2. Polarization calibrators for ALMA

Polarization observations will be part of the capabilities of ALMA with the goal of detecting polarization degrees of 0.1%. Initial testing will be performed during Cycle 1 in 2013. The needed correction will depend on the mount of the antennas (Az-Alt for ALMA) and on whether the feeds are measuring orthogonal linear or circular polarization (linear for ALMA). In all cases, the polarization of the source, and the instrumental polarization, will depend differently on the parallactic angle. To be able to chose calibrators close to different science targets, to be observed across large ranges in parallactic angle, a long list of calibrator sources is desirable, covering a large part of the sky (Fig. 2).

Since SiO maser emission from red giants is often strong and highly linearly polarized (e.g. Vlemmings *et al.* 2011), these sources are ideal for polarization calibration measurements, because a short exposure time will provide good calibration. The emission is expected to vary (see e.g. Ramstedt *et al.*, this volume), however, the correlation with e.g. pulsational period remains to be understood. Observations at different epochs show examples where the overall spectral shape stays essentially the same. The variability of the polarization characteristics over the pulsational cycle also remains to be evaluated.

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