

THE SPATIAL STRUCTURE OF SILICON MONOXIDE MASERS ⁺

Adair P. Lane
 National Radio Astronomy Observatory
 Edgemont Road
 Charlottesville, Virginia 22901

VLBI observations of stellar masers provide important constraints on models for maser excitation and for the dynamics and physical conditions in circumstellar envelopes. The spatial distribution and apparent sizes of SiO masers toward several late type variable stars and toward the star-forming region in Orion have been measured using the 75 km baseline between the 37 m telescope of Haystack Observatory and the 14 m telescope of the Five College Radio Astronomy Observatory. The fringe spacing is 0.02 arcsec and the transitions observed were the $v = 1, J = 1 - 0$ and $v = 2, J = 1 - 0$ lines at 43 GHz. The data were obtained in September 1979 and April 1982.

Assuming a Gaussian brightness distribution for individual features, the apparent sizes of the smallest features in the $J = 1 - 0$ lines toward Mira variables are $2 - 6 \times 10^{13}$ cm (FWHM); for the supergiant VX Sgr the sizes are $2 - 4 \times 10^{14}$ cm. The maser sizes and flux densities imply the masers are saturated. The peak brightness temperatures are in the range $5 \times 10^9 - 2 \times 10^{10}$ K.

Maps of the spatial distribution of maser features at different velocities have been obtained by analysis of relative phase as a function of time. Toward the Mira variable R Cas the $v = 1, J = 1 - 0$ masers occur out to distances of at least $4 R_*$ (1.5×10^{14} cm). The

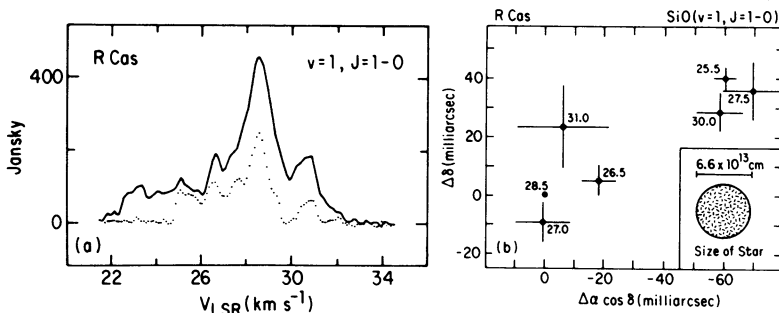


Fig. 1 - (a) Total and cross power spectra toward R Cas. ($V = 24.7$ km/s). (b) Map of SiO maser features toward R Cas.

+ Discussion on page 463

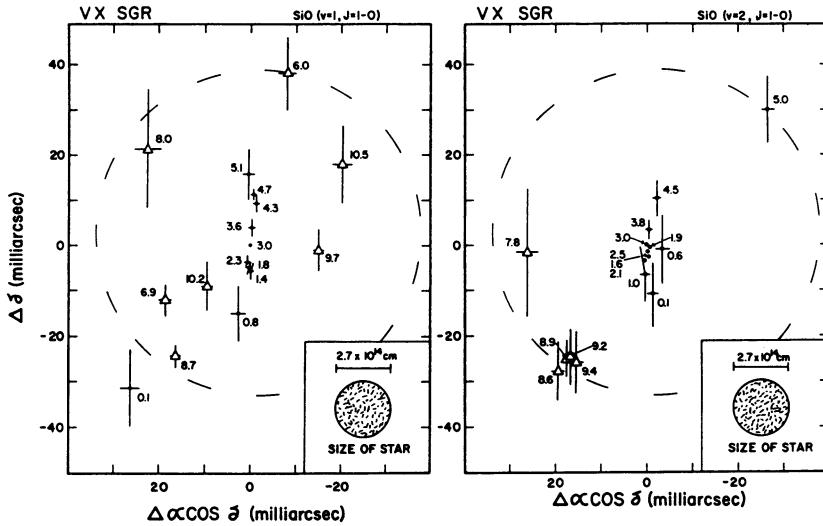


Fig. 2 - Maps of features in two SiO transitions from VX Sgr. ($V_* = 6$ km/s; Δ = redshifted features; \bullet = blueshifted features).

spatial distributions of the $v = 1, J = 1 - 0$ and $v = 2, J = 1 - 0$ masers toward VX Sgr are roughly similar to each other and are consistent with location of the masers in an expanding circumstellar shell of radius $6 R_*$ ($\sim 8 \times 10^{14}$ cm). Toward the Mira variable R Leo the masers are clustered closer to the stellar surface (within $2 R_*$ or 10^{14} cm) and do not show any clear kinematic pattern. A spatial offset of $\sim 10^{15}$ cm was measured between the two major groups of features toward Orion/IRc 2.

The data are inconsistent with a model locating the masers in convective cells in the stellar photosphere; instead it is more likely the masers are radiatively or collisionally pumped clumps of gas in the innermost turbulent regions of the circumstellar envelope.

The assistance of J. Moran, M. Reid, R. Predmore, and D. Clemens in obtaining the data is gratefully acknowledged.

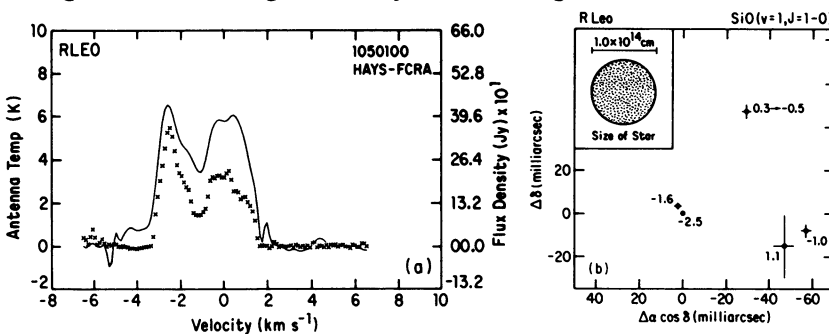


Fig. 3 - (a) Total and cross power spectra toward R Leo. ($V_* = -1.0$ km/s). (b) Map of SiO maser features toward R Leo.

*