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OBSERVATIONS OF SMALL-SCALE STRUCTURE IN AGB STAR WINDS: PRECURSORS OF NEUTRAL GLOBULES IN PNE?

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Millimeter-interferometric mapping of thermal emission from molecules which trace dense gas reveals much clumpy structure in the envelopes of two AGB stars. Observations were made with the Caltech OVRO mm-array. The signal-to-noise ratio of the data allowed use of self-calibration to achieve high dynamic range images ($\sim$ 100:1) in individual spectral channel maps of $0.7\,\mathrm{km\,s^{-1}}$ width. The angular resolution is $\sim 2''$.

The carbon star IRC+10216 was observed in the 236 GHz $J = 13$–12 line of SiS, the major carrier of gas-phase silicon. The M-giant IK Tau was observed in the 217 GHz $J = 5$–4 line of SiO. Sample channel maps are shown in Figures 1 and 2. In both cases, the gas is centrally concentrated, but shows many clumps distributed randomly about the star. Features at discrete velocities show continuity over several channels, interpreted as physically distinct clumps being ejected in a radial stellar wind outflow.

Spectra at single pixels in the maps show large asymmetries, and narrow components associated with the clumps seen most distinctly near the periphery of the emission. Feature widths are typically 2 to $5\,\mathrm{km\,s^{-1}}$, with intensities several times the rms noise. These spectra are consistent with a superposition of many discrete features at separate velocities, identifiable with clumps in the channel maps.

The spectra and maps suggest that > 100 discrete clumps are present in the stellar winds, with clump masses $< 10^{-4}\,M_{\odot}$. The dust clumps seen in high-resolution IR images (Tuthill et al. 2000; Weigelt et al. 2002) may be direct precursors. Observed linewidths imply the clumps expand supersonically, however, so will merge with ambient gas at radii $> 20''$, consistent with results of Huggins & Mauron (2002) but contradicting the model of Dyson et al. (1989) who assumed that quiescent clumps do become molecular globules in evolved PNe.

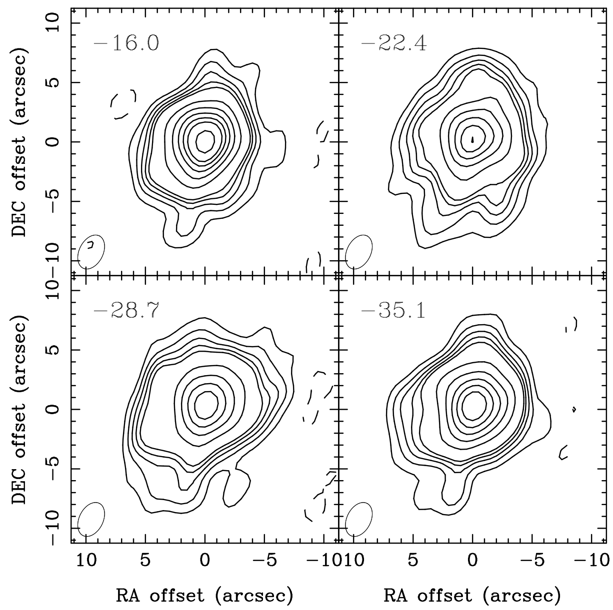

Fig. 1. Selected channel maps of SiS $J = 13$–12 emission from carbon star IRC+10216. The LSR velocity is given at the upper left of each panel. The contour levels are ± 1, 2, 3, 4, 5, 10, 15, 20,… Jy beam^{-1}.

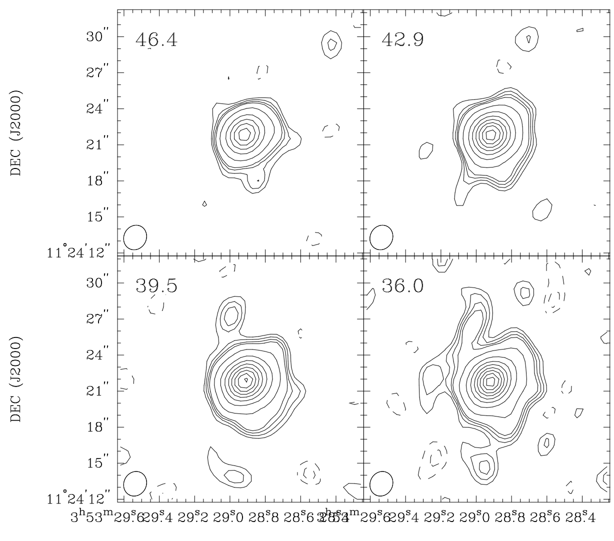

Fig. 2. Selected channel maps of SiO $J = 5$–4 emission from the wind of M-giant IK Tau. The contour levels are ± 0.2, 0.3, 0.4, 0.5, 1, 2,… Jy beam^{-1} with rms = 0.1 Jy beam^{-1}.

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