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SiO and H_2O Masers in the Central Parsec of the Galaxy

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Abstract. We have discovered maser emission from SiO and H_2O molecules toward a number of evolved stars within the central parsec of our Galaxy. The maser positions can be registered with milliarcsecond precision relative to the radio continuum emission of the nonthermal Galactic center source Sgr A*. Since the masing stars are prominent infrared sources, our data can be used to locate the position of Sgr A* on infrared images of the Galactic center region. Using VLBA observations it will be possible to measure proper motions of the maser stars, which can be used to put constraints on the mass distribution in the central parsec.

1. Masers Near the Galactic Center

Using the VLA, we have detected SiO and H_2O maser emission toward several sources within the central parsec of our Galaxy. These masers arise from the innermost parts of circumstellar envelopes of giant and supergiant stars that are members of the nuclear star cluster and appear as compact infrared sources in diffraction-limited 2.2 μm infrared images (see Menten et al. 1997). In Fig. 1 the positions of stellar sources that show maser action in the SiO, H_2O, and/or OH molecules are marked on a radio continuum map. Also shown are spectra of several of the maser sources (see Menten et al. 1997 for details of the SiO and H_2O observations and references to the OH data). One of the SiO masers is associated with the M-type supergiant IRS 7, the most prominent 2.2 μm point source in the Galactic center region.

Our radio data allow measurement of the maser positions relative to the compact non-thermal radio continuum source Sgr A* with milliarcsecond accuracy. Because stellar SiO masers near the Galactic center trace their host stars to within a few milliarcseconds (see, e.g., Diamond et al. 1994), these relative positions can be used to calibrate the plate scale and rotation of the infrared image (see Menten et al. 1997 for details). This method allows registration of the radio relative to the infrared reference frame with an estimated accuracy of $0\farcs03$. A $3'' \times 3''$ portion of a 2.2 μm infrared image is shown in the lower left corner of Fig. 1. The position of Sgr A* determined by the method described is marked by the cross whose size reflects the 2σ ($\pm0\farcs06$) uncertainty in the radio/infrared registration. Using the improved position accuracy we put a stringent upper limit on Sgr A*'s 2.2 μm flux density that is significantly lower than values predicted by recent theoretical model calculations.

In the future, multi-epoch VLBA measurements of the maser positions relative to Sgr A* will yield accurate proper motion determinations, allowing estimates of the central dark mass that can be compared to the value of 2.5×10^6 solar masses recently determined from infrared proper motion data (Eckart & Genzel 1996, 1997).

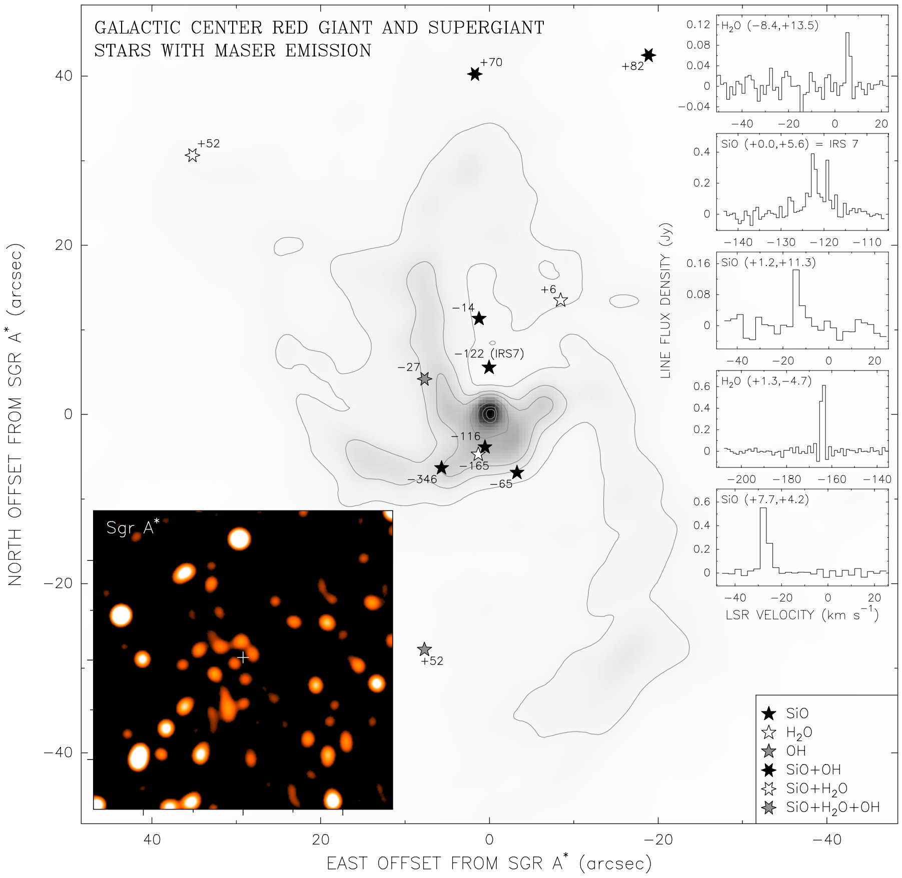

Figure 1. Late-type giant and supergiant stars within 2 pc of the Galactic center with known maser emission detected by the VLA. The size of the region plotted corresponds to an area of projected size 4 pc × 4 pc centered on the position of Sgr A*. Part of a 6 cm VLA radio continuum map (with 3$''$ resolution) is shown as a grey-scale representation with contours. Positions of maser stars are marked by various symbols and LSR velocities are indicated. As explained in the legend in the lower right corner, the symbols indicate which maser species are detected toward a given star. H_2O or SiO spectra observed toward some of the stars are shown in the inset on the upper right, with angular offsets from Sgr A* in arcseconds toward the East and North indicated. The inset in the lower left corner shows a 3$''$ × 3$''$ region of a 2.2μm infrared image centered on the position of the non-thermal radio source Sgr A*, which is marked by the cross.

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