OH 1720 MHz Masers in the Galactic Center: Sagittarius A East and the Circumnuclear Disk

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Abstract. We present new and archival Very Large Array (VLA) radio interferometry observations of the 1720 MHz OH masers in the Galactic Center (GC). Most 1720 MHz OH masers arise in regions where the supernova remnant Sgr A East is interacting with the interstellar medium. However, here we also present some previously detected positive velocity masers together with some newly detected negative velocity masers. In combination, those masers appear to bracket Sgr A* in position and velocity. The location and velocities of those masers are consistent with their being in the circumnuclear disk (CND).

1. Results from VLA observations
A large fraction of the Galactic Center 1720 MHz OH masers arise in regions where the supernova remnant Sgr A East is interacting with the interstellar medium (ISM). Their velocities are positive with values of about 40–60 kms⁻¹ consistent with the expansion velocity of the supernova remnant [2, 4, 5, 8]. However, a few masers have been detected that appear to have large velocity offsets as compared to the Sgr A East masers. Those include a bright maser detected multiple times at +132 kms⁻¹ [8], and a weaker maser detected at a single occasion at −132 kms⁻¹ [4].

In 2005 we conducted new, higher sensitive VLA observations to search for more masers with offset velocity in order to understand their nature. In addition, three VLA archival data sets had a velocity coverage, spatial resolution and sensitivity that were comparable to the new data. These three data sets were reduced and re-analyzed and used in combination with the new data. We detected 13 new and 13 previously published masers brighter than ten times the channel rms; two previous detections were not re-detected (see Fig. 1). Three new high-negative velocity masers confirm the existence of such masers after a single, never confirmed re-detection of the −132 kms⁻¹ maser. They are conjugate to the +132 kms⁻¹ masers with respect to Sgr A* and thus must originate in the CND. They are probably unsaturated, and therefore physically different from the SNR OH masers (in green in Fig. 1).

2. Nature of the offset velocity masers
The same VLA data also provides us with OH absorption data which shows that absorption around 60 kms⁻¹ occurs in the eastern part of the SNR shell, while absorption at lower velocities (≈ 20–40 kms⁻¹) also covers the western part of the shell (Fig. 2). This is consistent with the distribution of the +50 and +20 kms⁻¹ clouds that compose the major parts of the molecular belt.
extending over a large part of the Galactic Center. The most striking feature of the absorption data is that, at any velocity, little or no absorption can be seen against the minispiral and Sgr A*. While no absorption is seen towards the minispiral and Sgr A*, there appears to be weaker absorption along the western edge of the CND (seen for velocities between +100 and −115 kms\(^{-1}\)). The velocity structure of this absorption is in remarkable agreement with the HCN (J=1–0) emission which probes the CND via a clumpy and irregular ring structure [1, 3, 7]. The OH gas seen in absorption along the CND is therefore almost certainly part of the same circumnuclear ring as is the HCN emission.

The location of the OH gas does not give support for a direct interaction between the CND material and Sgr A East, ruling out the supernova remnant shock as the pump source for the high velocity masers. Instead the CND masers may be pumped by dissipation between clumps in the CND. We note that NICMOS imaging of the H\(_2\) line in the GC has revealed emission associated with the CND [9]. It is argued that dissipation of random motion of molecular clumps is the most likely cause of the excitation of the H\(_2\) molecules via shocks, implying the presence of C-type shocks within the CND. Similar to the C-shock chemistry predicted for SNR/ISM masers, the post-shock regions in the CND should produce suitable conditions for regions of enhanced OH abundances [6].

3. Conclusions
These results imply that 1720 MHz OH masers do not occur only in star-forming regions and in SNR/ISM interactions, but can also arise in clumpy and disturbed circumnuclear disks at small radii. If similar conditions occur in circumnuclear disks of extragalactic objects, sufficiently bright 1720 MHz OH maser lines could tentatively serve as an additional tool to study circumnuclear gas dynamics.

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Figure 1. OH 1720 MHz masers superimposed on our 1.7 GHz radio continuum. Numbers associated with symbols are the maser LSR velocities. Pluses and squares denote masers associated with the SNR shell (green), circles are masers associated with the CND (red and blue), and the diamond (pink) represents a newly detected though unrelated maser. The size of the symbol scales with the brightness temperature, except for the brightest maser at +66 km/s, for which the symbol size is divided by a factor of five in order to fit the symbol in the figure. The dotted semi-circle outlines the SNR G359.02-0.09 and labels A-D identify HII regions. As indicated, the large shell-like feature is the supernova remnant Sgr A East, and the bright spiral structure is known as Sgr A West.
Figure 2. Spectrally smoothed 1720 MHz OH absorption at velocities between +123 and −115 km s$^{-1}$. The absorption is shown in contours at 7.5, 15 and 22.5 mJy beam$^{-1}$, superimposed on a grey scale image of our 1.7 GHz radio continuum. The offsets are with respect to Sgr A*. No absorption is observed toward Sgr A* or the minispiral. Around the edge of the minispiral, the CND can been observed in absorption. Absorption at +58 and +37 km s$^{-1}$ mainly illustrates the extent of the molecular belt.