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A VLA Survey for Radio Pulsars in the Galactic Center

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Abstract. A radio pulsar in the Galactic center will suffer $350\,\nu_{\mathrm{GHz}}^{-4}$ *seconds* of pulse broadening. An imaging search for compact sources is far less desensitized by angular broadening than a periodicity search is affected by pulse broadening. We have conducted an imaging survey of the GC using the VLA and have detected approximately 200 sources. Six compact, steep-spectrum sources have been identified; additional compact sources with no spectral information have also been identified. Additional observations are in progress.

1. Radio Pulsars in the Galactic Center

The central 300 pc (2° at 8.5 kpc) of the Galaxy has the highest stellar densities in the Galaxy, with a central density near 10^8 $M_\odot$ pc^{-3}. This region contains clusters of hot, presumably young, massive stars; large-scale features thought to originate from powerful stellar winds and supernovae; and a concentration of X-ray binaries. The GC should also have a large population of radio pulsars, both recently formed and recycled. Radio pulsars in the GC would provide opportunities to probe its magnetoionic material, gravitational potential, and star formation. However, the pulsar census contains only a handful within a few degrees of the GC, none with distances in (or beyond) the GC.

Extreme pulse broadening causes this deficit of radio pulsars. Compact GC sources (Sgr A* and OH masers) display enhanced angular broadening, 1″ at 1 GHz (van Langevelde et al. 1992; Frail et al. 1994; Yusef-Zadeh et al. 1994); the implied pulse broadening is $350\nu_{\mathrm{GHz}}^{-4}$ *seconds* (Cordes & Lazio 1997).

A periodicity search would require $\nu \gtrsim 10$ GHz in order for the pulse broadening to be comparable to typical pulse periods. In constrast, sufficiently luminous compact sources (e.g., Sgr A* and the OH masers) can be imaged at much lower frequencies. Cordes & Lazio (1997) estimated that the GC contains 1–1000 sufficiently luminous pulsars, depending upon the vigor of recent starbursts.

We have observed the GC with the A-configuration VLA at a frequency of 1.4 GHz. The VLA provides a resolution of 1″.5, comparable to that expected for highly scattered GC sources. Furthermore, with a field of view of about 15′, the inner 1° of the GC can covered efficiently by an overlapping hexagonal grid.

2. Radio Pulsar Candidates

We identify radio pulsar candidates as compact, steep-spectrum objects. Based on the diameters of Sgr A* and the OH masers, pulsar diameters should be roughly $1''$. Spectral information is obtained from a cross-comparison of our survey with a 5 GHz survey of the GC (Becker et al. 1994).

We have detected (a) 3 sources with steep spectral indices; (b) 3 sources that should have been seen in the 5 GHz survey unless their spectral indices are $\alpha < -1$ ($S \propto \nu^{\alpha}$); and (c) 28 sources with the expected diameters for heavily scattered pulsars, but outside the latitude limit, $|b| < 0\overset{\circ}{.}4$, of the 5 GHz survey.

Additional 5 GHz VLA observations of these pulsar candidates have been obtained. Our objectives are (1) Verify or obtain the spectral index; and (2) Verify that source diameters scale as λ^2, as expected for scattered pulsars. Sources that are both steep spectrum and scattered will be subjects of a periodicity search at a frequency high enough to defeat pulse broadening ($\nu > 8$ GHz).

3. Supernovae in the Galactic Center

Supernovae may be a source of the 10^7 K, X-ray gas filling the central 1° of the GC, and their number provides a constraint on the vigor of recent starbursts. The number of supernovae is related to the number of pulsars (and candidates, Cordes & Lazio 1997): $N_{\rm psr} = f_v f_L f_b N_{\rm SN}$, where f_v is the fraction of pulsars with velocities low enough to remain bound to the GC, f_L is the fraction luminous enough to be detected, and f_b is the fraction beamed toward Earth. Cordes & Lazio (1997) estimated $f_v f_L f_b \sim 10^{-3}$–10^{-4}.

Using our 6 pulsar candidates, we can constrain $N_{\rm SN}$. We take $N_{\rm psr} \sim 10$. Clearly the number of pulsars could be smaller; the number could also be larger, though not by more than a factor of a few. We estimate $N_{\rm SN} \lesssim 10^4$–10^5 within the past few million years (approximate pulsar lifetime). This number is consistent with the number required to produce the X-ray emitting plasma ($\sim 10^3$) and number required to produce the 1.8 MeV emission from ^{26}Al ($\sim 10^5$).

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References

Becker, R. H., White, R. L., Helfand, D. J., & Zoonematkermani, S. 1994, ApJS, 91, 347

Cordes, J. M. & Lazio, T. J. W. 1997, ApJ, 475, 557

Frail, D. A., Diamond, P. J., Cordes, J. M., & van Langevelde, H. J. 1994, ApJ, 427, L43

van Langevelde, H. J., Frail, D. A., Cordes, J. M., & Diamond, P. J. 1992, ApJ, 396, 686

Yusef-Zadeh, F., Cotton, W., et al. 1994, ApJ, 434, L63