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A VLA Search for the Geminga Pulsar at 74 and 326 MHz

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Abstract. We have used the VLA to image the location of the gamma-ray pulsar Geminga at 74 and 326 MHz. Upper limits to the pulse-averaged flux density, taking diffractive scintillation (DISS) into account, are $S < 56$ mJy (2σ; DISS quenched) at 74 MHz and $S < 5$ mJy (95% confidence) at 326 MHz. Intrinsic variability appears to be required in order to reconcile our upper limits with previous low-frequency detections.

1. Introduction

Though initial speculation included the possibility that Geminga, the compact gamma-ray source in the Galactic anticenter, was a pulsar, its identification as such was not secure until the detection of X-ray pulsations (Halpern & Holt 1992; Bertsch et al. 1992). Since most pulsars are detectable at radio wavelengths, intense effort has been devoted to finding a radio counterpart to Geminga.

Until recently, only upper limits on Geminga's radio emission could be established. A number of groups have now reported pulsed emission near 100 MHz (Kuz'min & Losovskii 1997; Malofeev & Malov 1997; Shitov & Pugachev 1997; Vats et al. 1999), though subsequent attempts at 35 and 326 MHz failed (Ramachandran et al. 1998; McLaughlin et al. 1999). In an effort to constrain further the spectrum of Geminga, we conducted 74 and 326 MHz observations (Kassim & Lazio 2000)

2. Observations

The observations were conducted with the A-configuration VLA. Ionospheric variations would have vitiated a periodicity search, so only imaging observations were conducted. Calibration was performed within AIPS, using procedures similar to those for high-frequency data. One important aspect of imaging with the VLA at low frequencies is the sky cannot be approximated as flat. This "3-D" problem is severe at low frequencies because the primary beam is large. We used a polyhedron algorithm (Cornwell & Perley 1992) in which the sky is approximated by many 2-D "facets." Figure 1 shows our 74 MHz image of Geminga's location.

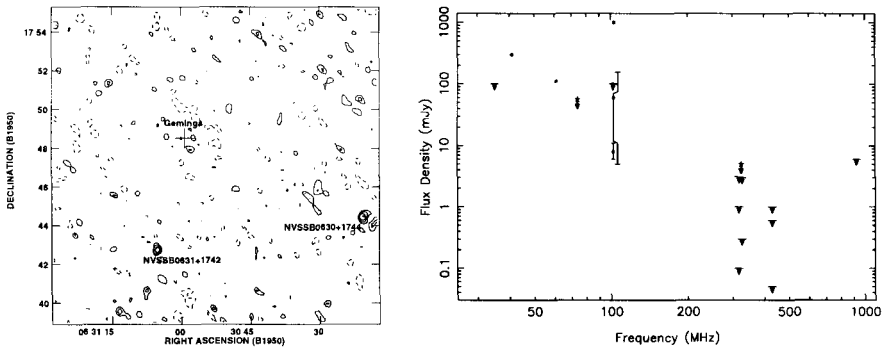

Figure 1. *(Left)* Geminga at 74 MHz. The angular resolution is 25″, and the rms noise level is 28 mJy beam^{-1}. The cross marks the location of the optical counterpart (Caraveo et al. 1998), and the sources NVSS B0630+1744 and B0631+1742 are marked for reference. The 326 MHz image is similar. *(Right)* The spectrum of Geminga.

3. Scintillation and Upper Limits on Geminga's Flux Density

Figure 1 shows the spectrum for Geminga below 1000 MHz, combining our upper limits with measurements in the literature. In establishing our upper limits, we accounted for the effects of diffractive interstellar scintillation by following the procedure developed by McLaughlin et al. (1999). For our observational parameters, DISS is quenched at 74 MHz. We therefore adopt $S < 56$ mJy, twice the rms noise. In contrast, DISS has a substantial impact at 326 MHz. The upper limit is $S < 5.0$ mJy (95% confidence).

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