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Towards an Understanding of the Galactic Distribution of Electron-Density Fluctuations

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Abstract. VLBA observations of 32 compact sources within $30^\circ \leq l \leq 75^\circ$, $|\, b \,| < 3^\circ$ are being used to test whether the galactic electron-density fluctuations contain a spiral component.

The scatter broadening of compact extragalactic radio sources seen through the Galaxy probes the large-scale distribution of the turbulent ISM. For Kolmogorov turbulence, the angular broadening at a frequency ν is $\theta_{FWHM}(\mathrm{mas}) \approx 130 SM^{+0.6} \nu(\mathrm{GHz})^{-2.2}$, where the Scattering Measure, $SM = \int_0^{s_{\mathrm{kpc}}} C_N^2(s')\, ds'$, is the line-of-sight integral of the scattering strength $C_N^2(\mathrm{m}^{-20/3})$, and s' is the distance. Thus, values of θ_{FWHM} can yield SM, and sufficient spatial sampling in l and b provide mapping of SM which can be unfolded to yield the distribution of scattering material in the ISM.

Attempts to interpret the distribution of interstellar turbulence via both scatter broadening and the low-frequency variability of extragalactic radio sources suggest that it possesses spiral structure, similar to other Population-I components (Fey et al. 1991, Ghosh & Rao 1992, Taylor & Cordes 1993). To establish whether this is so, we have undertaken a study of the scatter broadening within $30^\circ < l < 75^\circ$, $|\, b \,| \leq 3^\circ$. In this region, lines-of-sight pass progressively from the Sagittarius-arm tangent point, through the local inter-arm direction and into the Cygnus-Orion arm, allowing a straightforward test as to whether a spiral distribution really represents the scattering material. We have made VLBA observations of 32 compact sources within this region. Since intrinsic source sizes may also be frequency-dependent, we have observed at 0.33, 0.61 and 1.66 GHz, allowing us to separate scatter broadening from intrinsic sizes via the different frequency dependencies. The 1.66-GHz data are an order of magnitude more sensitive than those at 0.33 and 0.61 MHz, and are now imaged to first order. Low-frequency data calibration is nearing completion.

1. Results and Preliminary Conclusions

The 1.66-GHz imaging divides the sources into 3 classes: (a) 7 fully-resolved sources. Five are at $l < 34^\circ$ towards the Sagittarius arm implying that scattering is responsible. Just one is projected against the inter-arm region. This has the steepest spectrum in our sample and may be intrinsically broad. (b) Sources with very-extended Gaussian images, an unexpected morphology for flat-spectrum extragalactic sources. Almost all of these are projected against

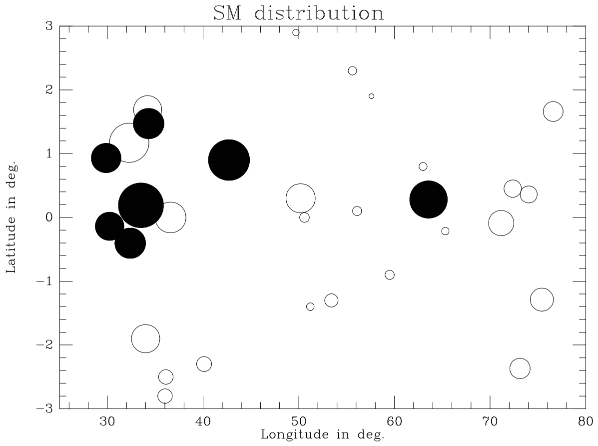

Figure 1. The "apparent SM" distribution from our 1.66-GHz images. The circles have radii $\propto SM^{1/3}$. Open circles represent upper limits on the SM derived from the deconvolved angular sizes, while filled circles are lower limits assuming that resolved-out sources are scatter broadened. Dotted circles are SM's from published work.

the Sagittarius and Orion arms, and are doubtless scatter broadened. Some have very elliptical images, explained naturally by anisotropy in the galactic electron-density fluctuations. (c) Sources with more complex structures, lying either at higher latitude or in the inter-arm direction. Among the double sources, a number of lower-l, higher-b cases show component pairs with similar-size pseudo-Gaussian forms, suggesting the influence of scattering. One such is 1910+052, lying on the rim of supernova remnant, W50, which contains the remarkable star, SS 433. Turbulence within the SNR could contribute to any scattering seen, and it will be of interest to see if the scattering of this source is at all anomalous.

While our present results represent but a single frequency, we can already get a feel for where they are leading. We have turned the measured 1.66-GHz component sizes, and the lower limits for resolved-out sources, into the values of SM which would produce these sizes. For the former, these are SM upper limits; for the latter, should scattering be solely responsible for their being resolved out, the values derived are lower limits on SM. Fig. 1 shows the resultant SM distribution in (l, b), including a few SMs from published work. The SM contrasts between the directions of the Sagittarius Arm, the inter-arm region, and the Cygnus-Orion Arm are very apparent and doubtless real. In addition, a b-dependence is seen towards the Sagittarius Arm.

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