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Recent Results on Magnetic Fields in the Milky Way

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Abstract. Of all the methods available to observe magnetic fields in the Milky Way, the mapping of linear polarization at cm wavelengths has proven to be most successful. The instruments that have contributed most of the new data are the 100 m Effelsberg telescope and the Parkes 64 m dish. Their Galactic plane surveys gave us a new conception of the linear polarization distribution. A new Effelsberg 1.4 GHz 'medium latitude polarization survey' now being made gives us data about large sections of the Galaxy. Polarization maps of selected regions of the Galaxy are now being made at several frequencies up to 32 GHz. Data from Westerbork at $\sim$ 325 MHz, as well as data from the Canadian Galactic Plane Survey (CGPS) at 1.4 GHz give new exciting information.

The linear polarization observed at radio frequencies allows us to determine the magnetic fields in our Galaxy. Observations between 408 MHz and 1.4 GHz by Brouw & Spoelstra (1976) showed the morphology of the local magnetic field as well as a field reversal towards $\ell = 140°$, $b = 8°$. At 2.7 GHz Junkes et al. (1987) showed that distant Galactic features could be observed in polarization. The southern and northern Galactic plane ($b = \pm 5°$) was mapped in polarization at 2.3 GHz and 2.7 GHz by Duncan et al. (1997, 1999). Uyanıker et al. (1999) mapped extended regions at 1.4 GHz as part of a 'medium latitude survey'. Observations at 325 MHz by Wieringa et al. (1993) showed filamentary polarization structure due to Faraday modulation. This work was extended by Haverkorn et al. (2000) showing RM 'jumps'. The Canadian Galactic Plane Survey (CGPS) showed large-scale interstellar Faraday rotation features (Gray et al. 1998). More recent CGPS maps of linear polarization show much detail, in particular the presence of magnetic field reversals.

Linear polarization is seen everywhere in each survey. Galactic sources, like SNRs, show considerable linear polarization. In addition large polarized areas 1°–5° across are present with no apparent corresponding total intensity sources. The polarization intensity in the inner Galactic plane ($b = \pm 2°$) is low, even at 2.7 GHz, indicating substantial Faraday depolarization. This suggests that regular magnetic fields are most concentrated to the inner Galactic plane. Faraday depolarization effects are even more obvious at 1.4 GHz where deep nulls, due to 90° vector jumps, lead to a variety of structures, even ten degrees away from the plane (e.g. Uyanıker et al. 1999). Multi-frequency maps of the same region are often very dissimilar in polarized intensity and suggest varying Faraday depth along the line of sight. Estimates of the RM in some areas give values of more than $\sim$100 rad m^{-2}, suggestive of strong magnetic fields.

There is observational evidence that the magnetic field of the Milky Way is confined to the inner plane region where it is apparently azimuthal. However, the magnetic fields in the Galactic center are vertical (e.g. Seiradakis et al. 1985). In addition a very turbulent local ISM is observed, where substantial Faraday depolarization takes place. This depolarization is due to random fields and varying thermal electron density in nearby clouds. Several field reversals, presumably nearby, have been observed. Extragalactic sources with known RM have been used to determine the magnetic field of the Galaxy (e.g. Simard-Normandin & Kronberg 1980). It must be noted that very few sources are actually observed within $b = \pm 5^\circ$ so that this interpretation relates more to the halo than to the disk of the Galaxy. A much greater sample of sources is needed. In deriving the magnetic fields from pulsars the foreground ISM must be considered. Magnetic field reversals may lead to an underestimate of the magnetic field strength. The results on Galactic magnetic fields and those on nearby galaxies seem at first to be different. However, a recent VLA map of NGC 4631 at 4.8 GHz by M. Krause shows depolarization structures similar to our Galaxy. The plane of NGC 4631 shows considerable depolarization, while polarized features are seen above and below the plane. Also 1.4 GHz maps of edge-on galaxies (NGC 891, NGC 4217, NGC 5775 etc.) show depolarization along the major axis.

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