# The Local Magnetic Field in the Milky Way

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**Abstract.** A radio continuum survey at medium Galactic latitudes with the 100-m telescope of the *Max-Planck-Institut für Radioastronomie* is being carried out at a center frequency of 1.4 GHz in total power and linear polarization. We present polarization and depolarization structures detected at medium latitititudes with no corresponding observable structure in total power emission. Existence of such kind of polarization structures imply that the emission, due to the Faraday modulation of the Galactic synchrotron foreground, occurs in thin sheetlike regions. This phenomenon is a sign for fluctuating local magnetic field.

## 1 Introduction

The Galactic area above $+4°$ and below $-4°$ has never been studied in a systematic way. Most large scale surveys, covering this area suffer from low angular resolution or they miss the diffuse emission as is the case for the VLA-survey (Condon et al. 1996). The knowledge of the magnetic field in the Galactic halo is still rather poor because of the lack of observations of the linear polarization at the proper angular resolution and sensitivity. To fill this gap new observations at 1.4 GHz are being carried out to cover the entire Galactic plane at medium Galactic latitudes ($|b| \leq 20°$) visible at Effelsberg. This survey is planned to reach a sensitivity at total power close to the confusion limit and a high sensitivity at linear polarization.

The observations are carried out with the two channel 1.3-1.7 GHz receiver installed in the primary focus of the Effelsberg 100-m telescope. The receiver is equipped with cooled HEMT amplifiers. The method of observation is to scan in Galactic latitude and longitude. The scanning speed is 4° per minute and the scan separation is 4′. The typical scan length is 10°. Each field was measured at least twice giving a total integration time per point of $\Delta t = 2$ s. A root mean square (r.m.s) value of 15 mK $T_B$ (or 7.5 mJy/beam area) for the total power is reached. This value is close to the expected confusion limit. The sensitivity of polarization measurements is found to be about 8 mK $T_B$ r.m.s. with $T_B/S_\nu = 2.11$ mJy/mK. The half power beam width (HPBW) at this frequency is 9.′4. The polarization is corrected for instrumental polarization down to about 1%. The total power maps are calibrated to an absolute scale using the 1.4 GHz northern sky survey by Reich (1981) and Reich & Reich (1986) made with the Stockert 25-m telescope. The polarization data are calibrated to an absolute scale using the data by Brouw

https://doi.org/10.1017/S0252921100071049 Published online by Cambridge University Press

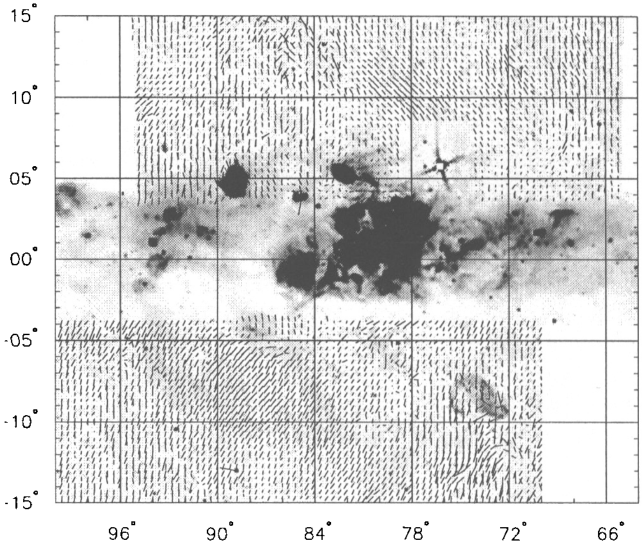


**Fig. 1.** A sample region from the 1.4 GHz continuum survey in gray scale. Electric field vectors are plotted as bars.

& Spoelstra (1976). A sample region from the survey is displayed in Fig. 1. Details of the survey are given by Uyanıker (1997).

In the following sections we present examples of the detected polarization structures and discuss their origin and importance for the understanding of the local magnetic field in the Milky Way.

## 2 Polarization Structures

Variations of the linear polarization are common at medium latitudes. These structures are close to highly polarized regions. In some examples the polarization intensity suddenly drops to a certain value and forms filamentary or loop like structures just in the middle of a highly polarized region. They are like lenghty slits in relatively high polarization regions. The electric field vectors of the linear polarized signal seem to follow these structures. A representative example of such a filament is given in Fig. 2.

Towards the Cygnus region, below the well-known supernova remnant Cygnus Loop, a polarization structure is detected (Fig. 3). The structure is about 6°.2 × 5°.6 in dimensions, in longitude and latitude respectively. Polarization vectors form two arc like structures touching each other. The magnetic field vectors form an elliptical shape giving the impression as if it is an ellipsoidal object. No corresponding variation in the total power emission has been seen.

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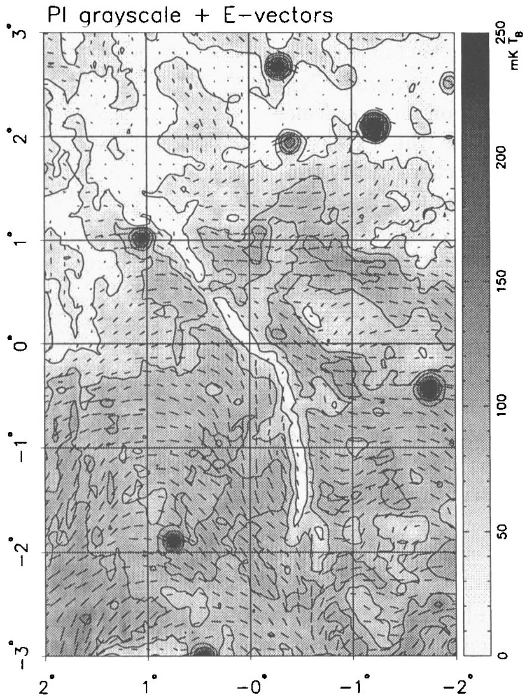


**Fig. 2.**
Depolarization filament towards Galactic anti-center. The filament is at least 4° in length. The upper part of the filament makes an angle of 40° with the north and the lower part is more or less perpendicular to the Galactic plane. Electric field vectors follow the structure. The width of the filament is about 10′ after correcting for the beam. This depolarization filament is most probably caused by the Faraday modulation of the local magnetic field. Relative coordinates are in units of degrees.

## 3 Discussion

It is known that polarization structures without corresponding variation in total power emission exist (see Wieringa et al. 1993). This is mainly due to the fact that at least half of the magnetic energy density in the interstellar medium is in the form of fluctuations (see Heiles 1996, Zweibel 1996). Since the polarized emission can not traverse great distances without beeing depolarized, the sources of polarized emission are generally rather nearby. It seems that the observed structures are closely connected with the fluctuating local magnetic field. In this way the filamentary structures of low polarization intensity may be interpreted as depolarization caused by Faraday modulation of synchrotron foreground. Therefore, at shorter wavelengths, due to the wavelength dependency of the Faraday rotation, these depolarization structures are expected to disappear or at least weaken. If however the structures are still observable at shorter wavelengths (than 21 cm), one should consider the interaction of magnetic fields, namely magnetic reconnection effects. On the other hand, depolarization can also result due to the finite beamwidth of the telescope (beam depolarization). If several regions of emission with different rotation measures simultaneously exist within the beam then the measured polarization is not a function of $\lambda^2$ (see Burn 1966). Alternatively, if the spectral index of the radiation varies within a small region then the

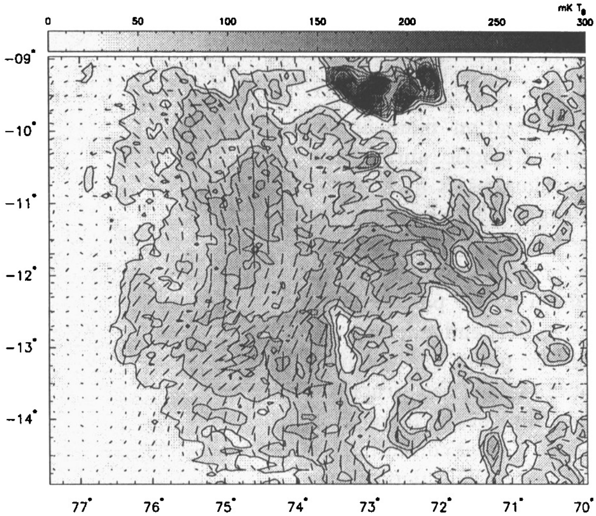


**Fig. 3.** Polarization structure towards Cygnus region in grayscale. To make the extent of the structure clear, contours are plotted as given in the wedge. The two uniform arches drawn by the electric field vectors can be seen easily. Magnetic field vectors, when plotted, form an elliptical shape. Percentage polarization varies between 5 to 16% across the structure.

polarization of the different components dominate at different wavelengths. Therefore, a detailed spectral information about these regions is necessary. We leave this question open until the observations at higher frequencies are available.

The interaction between the Galactic magnetic field and interstellar clouds leads to a variety of radio emitting structures, shells, filaments, and loops. Many of these features are linearly polarized. They extend up to large Galactic latitudes. They are very faint, an order of magnitude fainter than the large scale diffuse Galactic emission. They deform and compress the Galactic magnetic field. The detected polarization structures indicate that the local Galactic magnetic field is not constant. There are disturbances of the smooth background due to Faraday modulation of the magnetic field.

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