THE LARGE-SCALE MAGNETIC FIELD STRUCTURE NEAR THE GALACTIC CENTRE

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ABSTRACT. High frequency polarization observations reveal the existence of a poloidal magnetic field structure in the Galactic Centre region on scales of about 200 pc. At lower frequencies large non-thermal spurs are seen tracing the magnetic field up to kpc distances from the Galactic Centre.

The well known mixture of thermal and non-thermal emission structures close to the Galactic Centre region requires high frequency observations to trace the magnetic field structure. Fig. 1 shows a preliminary 32 GHz map observed with the Effelsberg 100-m telescope of the "arc" region. This is a bar-like structure running almost perpendicular to the Galactic plane at a distance of about 0°.2 from Sgr A. 32 GHz is a frequency high enough that rotation measures of several thousand rad m^{-2} are required to cause a significant rotation of the observed polarization angles from the intrinsic magnetic field direction. In Fig. 1 a very regular magnetic field structure is seen running along the arc with polarization percentages close to 50% (for $-5' \geq b \geq -10'$). This percentage polarization is near to the intrinsic value of about 60% for the non-thermal flat spectrum emission seen in this region (Reich et al., 1988a). The equipartition magnetic field strength is about 135 μG. Strong thermal filaments crossing the arc at b = -2' (Yusef-Zadeh et al., 1989) cause complete depolarization. North of this region the percentage polarization is about 30%. This implies the existence of a non-thermal component with a fraction of at least 60% of the total emission, beside a weaker thermal component as indicated by recombination line observations. A rotation measure of about -10000 rad m^{-2} is expected for this region for the case that the magnetic field direction continues to run parallel to the arc structure.

The arc connects two large highly polarized plumes north and south of the Galactic plane. These have been observed with the 100-m telescope at 10.7 GHz (Seiradakis et al., 1985; 1989) as shown in Fig. 1. From two rotation measure determinations (Sofue et al., 1987; Tsuboi et al., 1986) the magnetic field direction was found to run perpendicular to the Galactic plane. This has been taken as evidence for the existence of a poloidal magnetic field component in the Galactic Centre region on

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scales of at least 200 pc (8.5 kpc Galactic Centre distance).

A larger region around the Galactic Centre has been mapped at 1408 MHz in the course of a survey of the Galactic plane (Reich et al., 1990) and is shown in Fig. 1 after subtraction of the diffuse large-scale emission. North of the Galactic plane the so-called Galactic Centre Lobe (Sofue and Handa, 1984) centered at $l \cong -0.^{\circ}2$ and $b \cong 0.^{\circ}6$ is visible, which is believed to be completely non-thermal although its spectrum is flat (Reich et al., 1988b). Two large non-thermal ridges are seen at positive latitudes connecting the Galactic Centre region with a non-

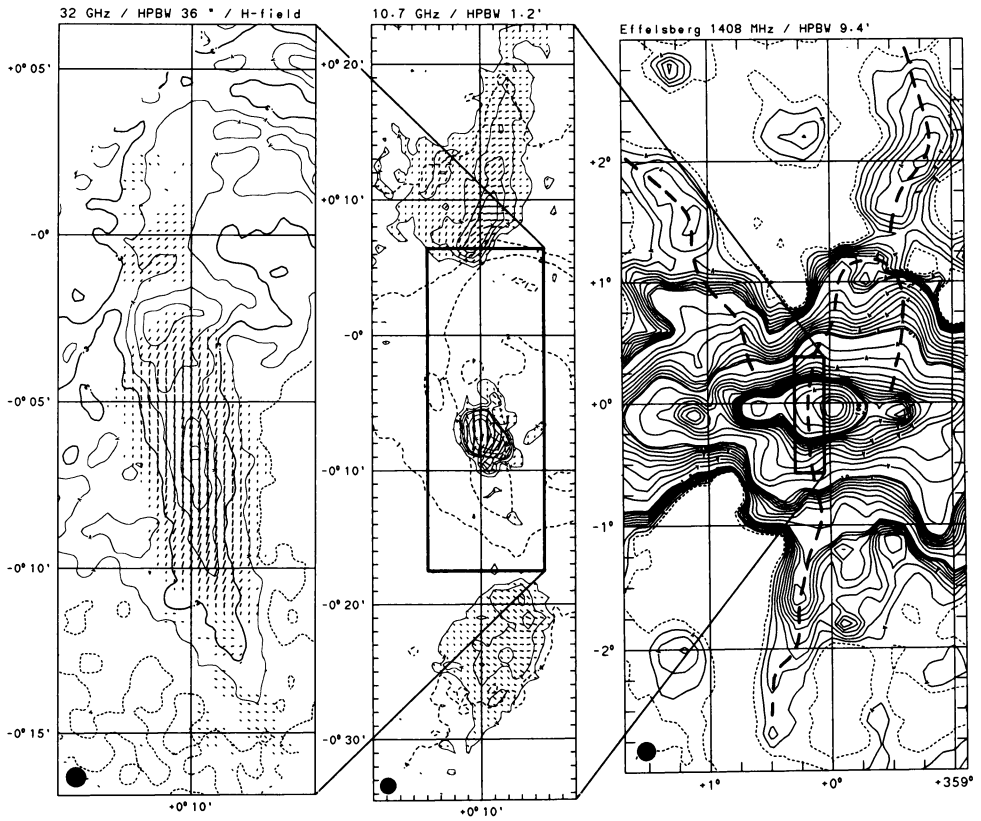

Figure 1. The Galactic Center region as observed with the Effelsberg 100-m telescope at 32 GHz, 10.7 GHz and 1.408 GHz. The HPBW is always indicated. At 32 GHz contours are shown at 150 mJy/beam area intervals. Polarization bars are shown above 40 mJy/beam area in H-field direction for the case of no Faraday rotation. At 10.7 GHz full contours show polarized intensities in steps of 50 mJy/beam area. Polarization bars are in E-field direction. Some total intensity contours are shown dashed. At 1.408 GHz contours are shown for 0.15 K (or 75 mJy/beam area), 0.3 K, .., 1.5 K, 2.5 K, .., 9.5 K, 10 K, 15 K, .., 75 K, 100 K, 150 K, .., 550 K.

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thermal spur running to latitudes as high as 24° (Sofue et al., 1989a,b). Its spectral index is close to $\alpha = -0.7$ ($S \propto \nu^{\alpha}$). If this structure is in fact physically connected with the Galactic Centre as argued by Sofue et al. (1989a,b), it has a length of 4 kpc and a width of about 200 pc. Similar jet-like structures on kpc scales have been reported for some edge-on spiral galaxies before (Duric et al., 1983).

At 1408 MHz a new feature is visible at negative latitudes forming an extension of the arc structure. This non-thermal spur can be traced to a distance of about 2°.8 from the Galactic plane (as indicated in Fig. 1). Its projected length is about 400 pc. The intensity of this ridge decreases by a factor of about 500 from the arc region to its highest latitude. Its spectral index below a latitude of $-1°$ is about $\alpha = -1$ in the frequency range 1.4 GHz to 2.7 GHz, which is significantly different from the flat spectrum emission in the arc region.

Although polarization data for both the positive and negative latitude spurs are not yet available their non-thermal nature implies the existence of a large-scale magnetic field component in the Galactic Centre region perpendicular to the Galactic plane.

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F. KRAUSE: I think we can understand the vertical, rather homogeneous magnetic field in the central part of the Galaxy in the case in which there is an α^2 dynamo working in a part of the Galactic disk with radial extensions up to 500 pc. My question is whether there are observational indications of an azimuthal magnetic field at distances of about 300 pc from the center which has about the same order of magnitude as the vertical field near the center. The α^2 dynamo needs this field component because it has to provide the necessary azimuthal currents.

REICH: Except for the polarized lobes no other polarized emission within a distance of 300 pc or ~2° from the Galactic Center has been detected so far. Upper limits are given by the 10 GHz observations of the Galactic Center region by Tsuboi et al. (1986, Astron. J. 92, 818).

BICKNELL: One way to determine whether the high latitude feature you discussed is a jet would be to plot surface brightness against width and compare with class I extragalactic radio sources.

HUMMEL: I want to remind you that there is some information on the linearly polarized emission in about a dozen nuclei in normal and mildly active spiral galaxies. In a few of these there is clear evidence of radio continuum structures perpendicular to the plane, reaching heights of a few kpc. The equipartition magnetic field strength determined in these structures is about 15 to 30 μG.

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