A NEW LOOK AT THE GALACTIC MAGNETIC FIELD

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We have measured the linear polarization of a new large sample of extragalactic radio sources, and by combining these with polarization values already in the literature, we have been able to compute a large number of rotation measures, with improved quality. We have also investigated the depolarization properties of these sources and as a result have been able to identify most sources with a large internally generated Faraday rotation. Figure 1 shows the rotation measures of 475 extragalactic radio sources on an equal-area projection, after "cleaning out" the extragalactic effects to first order.

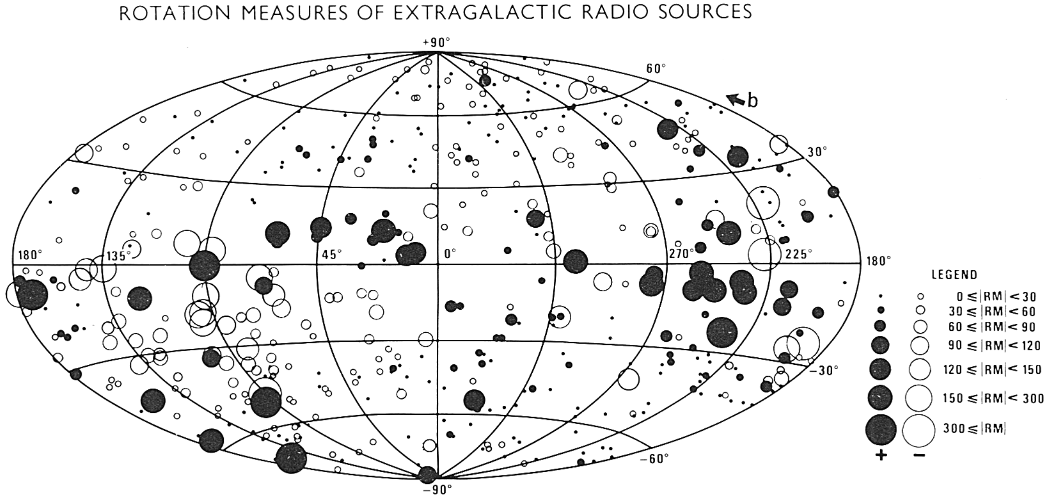

Figure 1 Rotation measures of a subset of 475 extragalactic radio sources that are statistically unlikely to have large internally generated RM's.

W. B. Burton (ed.), The Large-Scale Characteristics of the Galaxy, 317–319.

In the southern galactic hemisphere the RM's suggest a prevailing magnetic field pointing towards $\ell \sim 90^\circ$ and coming from $\ell \sim 255^\circ$. This systematic pattern persists all the way to the south galactic pole, and also agrees with the prevailing trend in the second and third quadrants ($90^\circ \lesssim \ell \lesssim 270^\circ$) in the northern hemisphere. Only above the plane and towards the galactic centre ($270 \lesssim \ell \lesssim 90$) is the general trend of RM's reversed - this is the region occupied by loop I. This "reversal" has previously been observed by Vallée and Kronberg (1975) and Gardner, Morris and Whiteoak (1969).

The most prominent feature in the RM sky is located at $45^\circ \lesssim \ell \lesssim 160^\circ$ and $-40^\circ \lesssim b \lesssim +10^\circ$ and contains surprisingly high negative RM's $-60 \gtrsim RM \gtrsim -200$ rad m^{-2} to quite large negative latitudes (Fig. 1). The predominance of this large feature has not previously been recognized in earlier RM maps with fewer sources.

The vast majority of sources at $|b|>30^\circ$ have small rotation measures ($|RM|<30$ rad.m^{-2}), and the large-RM zones are virtually free of small-RM sources. At $\ell \sim 90^\circ$, the RM's are much smaller at $b>10^\circ$ than $b<-10^\circ$. The influence of loop I on the RM map is much smaller than the large RM features near $\ell \sim 255^\circ$ and $\ell \sim 90^\circ$, and loop III has no corresponding large scale RM feature. Loop II encircles the large feature below the plane, although the physical significance of this positional coincidence is not yet clear.

Another strong feature of positive RM is centered at $\ell \approx 40^\circ$, $b \approx +5^\circ$. Between this feature and the strongly negative zone near $\ell \sim 90^\circ$ below the plane the RM's change abruptly from large positive to large negative values. These features are consistent with a large scale magnetic field directed in the sense of galactic rotation between the Sagittarius and Perseus arms, and in the opposite direction between the Norma-Scutum and Sagittarius arms, in the first two quadrants of galactic longitude.

REFERENCES

Gardner, F.F., Morris, D. and Whiteoak, J.B.: 1969, Aust. J. Phys., 22, 813.

Vallée, J.P. and Kronberg, P.P.: 1975, Astron. and Astrophys., 43, 233.

DISCUSSION

Cesarsky: Previous maps (e.g., Wright) showed much more disorder in the magnetic field directions, and were interpreted as meaning that the galactic magnetic field consists of an ordered and a disordered component, of similar strengths. Measurements of the magnetic field that average over a distance large compared to the scale of the irregularities can only give a measure of the mean, or the possibly ordered component, of the magnetic field. Could, in fact, the disordered component dominate?

Kronberg: The rotation-measure technique is of course more sensitive to ordered fields. It would be premature to give a quantitative value to the ratio B ordered/B disordered. Nevertheless, one can deduce that for the large-scale regions that we see, the absence of small rotation measures is an indication that this ratio must be at least, and probably greater than, one.

Felten: It is worthwhile to emphasize the point that Dr. Cesarsky raised: There may be a sizable random component to the field as well as a uniform component. People should not assume from these studies that the field is smooth, uniform, and directed along spiral arms. If you took a cloud containing a perfectly tangled field, and stretched it along one dimension, you would get a field which would still be tangled. It would have a random component, but it would still give high radio polarization. This could be a realistic model for an interstellar cloud. Until Dr. Kronberg can give us a ratio of the random component to the uniform component, we cannot say how tangled the field is.

Berkhuijsen: At a wavelength of 11 cm, using the Bonn telescope, we have detected polarized emission from the southern part of the bright ring in M31. With a beamwidth of 4!5 (∿ 1x4 kpc in the plane of M31), we find percentages of polarization of 10 to 20%, with some peaks of more than 30%. A magnetic field along the spiral arm is consistent with out data, but observations at other wavelengths are needed to confirm this. A letter has been submitted to A.&A. about this work by Beck, Berkhuijsen, and Wielebinski.