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PULSAR ROTATION AND DISPERSION MEASURES AND THE GALACTIC MAGNETIC FIELD

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ABSTRACT

Observations of pulsar polarization and pulse time of arrival at frequencies between 250 and 500 MHz have been used to determine rotation and dispersion measures for 19 and 21 pulsars, respectively. These measurements have been used to calculate mean line-of-sight components of the magnetic field in the the path to the pulsars. These and other observations show that there is probably no contribution to the observed rotation measure from the pulsar itself. Low-latitude, low-dispersion pulsars are observed to have strong field components, and a strong dependence of rotation-measure sign on galactic longitude has been found. The observations are consistent with a relatively uniform field of about 3.5 microgauss directed toward about $l = 90°$ in the local region, but appear to be inconsistent with the helical model for the local field.

I. INTRODUCTION

Pulsars are ideal probes for study of the interstellar medium. Observations of the pulse dispersion as a function of frequency provide a measure of the column density of electrons in the line of sight to the pulsar, and hence an approximate value for the pulsar distance. Pulsars are often highly linearly polarized. Faraday rotation of the plane of polarization occurs in the intervening medium, and measurements of position angle over a range of frequencies give the corresponding rotation measure. Combining this with the dispersion measure, we obtain a value for the mean line-of-sight component of the magnetic field in the path. This value is weighted by the thermal-electron density and, in most cases, provides a good estimate of the general interstellar or galactic magnetic field. The direction of the field component is given by the sign of the rotation measure.

Prior to the discovery of pulsars, only the Zeeman effect seen in H I absorption lines was able to give quantitative values for the magnetic field strength. These observations have been successful in several radio sources having deep absorption lines (Verschuur 1969*a*), but they give the field strength in the absorbing H I cloud rather than in the general interstellar medium (Verschuur 1969*b*).

Observations of Faraday rotation of emission from polarized extragalactic sources provide information on the structure of the galactic magnetic field. These observations have been interpreted as indicating a longitudinal field directed along the local spiral arm with either opposite signs above and below the galactic plane (Berge and Seielstad 1967) or the same sign above and below the plane but with deformations around 0° longitude (Gardner, Morris, and Whiteoak 1969). Measurements of the polarization of starlight give the direction of the field component perpendicular to the line of sight. These observations generally refer to relatively local regions, within about 500 pc of the Sun. Mathewson (1968) has fitted these data with a field model consisting of tightly wound helices having an axis in the $l = 90°$, $270°$ direction. The helices are sheared in a counterclockwise sense by an angle of 40° looking down from the north galactic pole. This model also provides a possible explanation for the spur features of galactic radio emission. To account for the distribution of rotation measures, Mathewson and Nicholls

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(1968) added a longitudinal field directed toward $l = 90°$ (above and below the plane) to the helical model.

The number of pulsars now known is sufficient to permit a study of the galactic magnetic field. Observations presented below are consistent with a relatively uniform longitudinal field in the local region directed toward about $l = 90°$ both above and below the plane. The maximum field strength observed is about 3.5 microgauss.

II. OBSERVATIONS

Pulsar rotation measures can be determined by two methods. In observations with a linearly polarized feed at low frequencies (~100 MHz), rotation of the plane of polarization results in a sinusoidal variation in pulse amplitude as a function of frequency for highly polarized pulsars. The magnitude of the rotation measure can be calculated from the spacing between amplitude maxima in the spectrum. This method has been successfully employed by Staelin and Reifenstein (1969), Vitkevich and Shitov (1970), and Shitov (1971).

An alternative method consists of direct measurement of the position angle of the linearly polarized part of the pulse at a number of frequencies. This is basically the method used in determining rotation measures for continuum sources, and both the sign and the magnitude of the rotation measure are obtained. By using the integrated pulse profile, rotation measures can be determined for relatively weakly polarized pulsars. This method, first used by Smith (1968*b*), has been employed in the present observations which were made on the National Radio Astronomy Observatory 92-m transit telescope in several observing sessions during 1970 and 1971. The major sessions were 1970 April 12–25 and 1971 February 23–March 3. Except for the addition before the second major session of a broad-band feed having good efficiency in the range 250–500 MHz, the observing system was essentially the same as that described by Manchester (1971*a*).

During each transit of a given pulsar the integrated pulse profile and linear polarization parameters were measured at 410 MHz and a second frequency. Profiles and polarization data at 410 and 1665 MHz have been given by Manchester (1971*a*) for most of the pulsars discussed here. By cross-correlating the integrated profile with a standard profile for each pulsar, absolute times of pulse arrival were determined for the two frequencies observed each day. Probable errors in arrival times were frequently less than 100 μs. Dispersion measures were then calculated from these results as follows. After correcting the arrival times from a given observing session for the propagation time to the solar-system barycenter, a second-order curve was fitted through points at the reference frequency (410 MHz). The time offset from this curve was calculated for points at other frequencies and the dispersion constant (DC), defined by

$$\mathrm{DC} = (t_1 - t_2)/(1/f_1^2 - 1/f_2^2) , \tag{1}$$

where t_i is the arrival time (s) of a given pulse at frequency f_i (Hz), calculated for each offset point. These values were then averaged with a weight proportional to the inverse square of their estimated error. The final result is therefore heavily weighted toward measurements at large frequency spacings. The dispersion measure (DM) was calculated by using

$$\mathrm{DM} = \int n_e dl = 2.410 \times 10^{-16}\,\mathrm{DC} , \tag{2}$$

where n_e is the electron density in cm^{-3}, l is in parsecs, and the integral is over the line of sight to the pulsar.

Dispersion constants and dispersion measures derived from the observations are given in Table 1 for 21 pulsars. The frequency range within which the observations were made is also listed, and quoted errors are 1 standard deviation of the weighted measurements. For PSR 0525+21 and PSR 0531+21 previously published values are given.

TABLE 1

ROTATION AND DISPERSION MEASURES

PSR	l (deg.)	b (deg.)	Frequency Range (MHz)	DC (10^{16} Hz)	DM (cm^{-3} pc)	RM (rad m^{-2})	$\langle B_{l,e} \rangle$* (microgauss)
0329+54....	145	−1	280–485	11.110 ±0.002	26.776±0.005	−63.7±0.4	−2.93 ±0.02
0525+21....	184	−7	281–421	21.07 ±0.05†	50.8 ±0.1†	−39.6±0.2	−0.960±0.006
0531+21....	185	−6	365–414	23.5705‡	56.805‡	−42.3±0.5	−0.92 ±0.02
0809+74....	140	+32	365–421	2.42 ±0.03	5.84 ±0.06	−11.7±1.3	−2.5 ±0.3
0818−13....	236	+13	365–421	16.97 ±0.04	40.9 ±0.1	− 2.8±1.7	−0.08 ±0.05
0834+06....	220	+26	365–414	5.35 ±0.02	12.90 ±0.04	+24.5±2.5	+2.3 ±0.3
0950+08....	229	+44	280–421	1.230 ±0.003	2.965±0.007	+ 1.8±0.5	+0.7 ±0.3
1133+16....	242	+69	280–421	2.006 ±0.003	4.834±0.007	+ 3.9±0.2	+0.99 ±0.06
1237+25....	252	+87	365–414	3.840 ±0.004	9.254±0.008	− 0.6±0.4	−0.07 ±0.05
1508+55....	91	+52	281–421	8.133 ±0.005	19.60 ±0.02	+ 0.8±0.7	+0.05 ±0.04
1604−00....	11	+36	365–410	4.45 ±0.02	10.72 ±0.05	...	...
1642−03....	14	+26	365–421	14.816 ±0.004	35.71 ±0.01	+16.5±2.5	+0.58 ±0.09
1706−16....	6	+14	365–421	10.37 ±0.03	24.99 ±0.08	...	...
1818−04....	26	+ 5	365–421	35.06 ±0.04	84.48 ±0.08	+70.5±7.5	+1.0 ±0.1
1911−04....	31	−7	365–414	37.10 ±0.02	89.41 ±0.04	...	...
1929+10....	47	−4	365–410	1.318 ±0.001	3.176±0.003	− 8.6±1.8	−3.3 ±0.7
1933+16....	52	−2	365–421	65.78 ±0.02	158.53 ±0.05	− 1.9±0.4	−0.015±0.003
2016+28....	68	−4	365–421	5.88 ±0.01	14.16 ±0.03	−34.6±1.4	−3.0 ±0.2
2021+51....	88	+ 8	365–414	9.369 ±0.002	22.580±0.004	− 6.5±0.9	−0.36 ±0.05
2045−16....	31	−33	281–410	4.775 ±0.004	11.51 ±0.01	−10.8±0.4	−1.15 ±0.04
2111+46....	89	−1	365–414	58.6 ±0.2	141.4 ±0.4	−223.7±2.2	−1.95 ±0.03
2217+47....	98	−8	365–414	18.06 ±0.02	43.52 ±0.05	−35.3±1.8	−1.00 ±0.05
2303+30....	98	−27	365–410	20.70 ±0.05	49.9 ±0.2	...	...

* A positive field component is directed toward the observer.
† Manchester (1971*b*).
‡ Richards *et al.* (1970).

Rotation measures were calculated as follows. The rotation between 410 MHz and the other frequency at which observations were made on a given day was determined by calculating the differences in position angle on a point-by-point basis across the aligned integrated profiles. These differences were then averaged with a weight inversely proportional to the square of their error, and corrected for the ionospheric contribution to the rotation. Continuous records of the total ionospheric Faraday rotation, derived from observations of the geostationary satellite ATS III, were obtained from the University of Illinois Ionosphere Radio Laboratory for the periods of the observations. The ionospheric correction for each observation was calculated on the assumption of a flat, horizontal ionosphere and a uniform magnetic field at the appropriate dip angle. It was generally between +0.1 and +6 rad m^{-2} depending on the time of day and the declination of the pulsar.

The position angle relative to that at 410 MHz was determined for each pulsar at several frequencies within the range given in Table 1 by using the above method. The number of frequencies ranged between two and seven for different pulsars, and there were frequently several independent measurements at a given frequency. Measurements at small frequency spacings were always sufficient to determine unambiguously the number of complete 180° cycles to be added to the rotation at a given frequency. This number was frequently large; for example, for PSR 0329+54 there are more than 12 complete cycles between 280 and 410 MHz. The rotation measure (RM), defined by

$$\mathrm{RM} = (\phi_1 - \phi_2)/(\lambda_1^2 - \lambda_2^2)\ , \tag{3}$$

where ϕ_i is the position angle (rad) at wavelength λ_i (m), was then calculated for each independent measurement and the average rotation measure calculated in the same way as the average dispersion constant. Rotation measures determined in this way are given in Table 1 for 18 pulsars. The value for PSR 0531+21 was calculated by a slightly different method which has been described by Manchester (1971*c*). The parameters quoted here for this pulsar differ slightly from those in the previous reference because of a small change in the ionospheric correction. Also, because of the different analysis procedure, values given for PSR 0525+21 are slightly different from those previously published (Manchester 1971*b*).

The mean line-of-sight component of the magnetic field in the path to the pulsar, calculated from the rotation and dispersion measures by using

$$\langle B_{l,e}\rangle = \int B_l n_e dl / \int n_e dl = \mathrm{RM}/(0.812\ \mathrm{DM})\ , \tag{4}$$

where B_l is the line-of-sight field component in microgauss, is given in Table 1 for each pulsar. Contributions to this mean field are weighted by the local electron density, so it will equal the average field component only if fluctuations in the electron density and magnetic field strength are uncorrelated. Ionization of the interstellar medium (by ultraviolet radiation, X-rays, or cosmic rays) is not directly dependent on the magnetic field strength, so strong correlations between the electron density and field strength would not be expected. This point will be discussed further below. The field component has been given the same sign as the rotation measure, so a field directed toward the observer has a positive sign. This convention is opposite to that used by Verschuur (1969*a*).

The intrinsic angle of the pulsar emission, defined as the position angle at infinite frequency, can be calculated from the rotation measure and the position angle at some frequency. In Table 2 the position angle above the ionosphere at 410 MHz, measured from north through east, is given for the 19 pulsars for which rotation measures were obtained. The angle quoted is that at the center of symmetry of the position-angle curve (generally equal to the position angle at the midpoint of the pulse) and was obtained by averaging all observations at 410 MHz made during the major 1971 observing

TABLE 2

POSITION ANGLES

PSR	ϕ_{410} (deg.)	ϕ_I (deg.)	ϕ_G (deg.)	Extrapolated ϕ_{1665} (deg.)	Observed ϕ_{1665} (deg.)
0329+54...	100± 5	70±20	35±20	135±20	142±10
0525+21...	89± 5	40±10	165±10	...	...
0531+21...	106± 5	145±20	85±20	65±20	60±10
0809+74...	94± 5	90±40	170±40	...	...
0818−13...	32± 8	120±60	60±60	...	...
0834+06...	135± 5	105±80	45±80	...	...
0950+08...	36± 3	160±20	100±20	165±20	10± 5
1133+16...	36± 3	95±10	40±10	105±10	130± 5
1237+25...	160± 4	0±15	130±15	175±15	10±10
1508+55...	45± 5	20±25	145±25	25±25	25±10
1642−03...	10± 5	40±85	95±85	...	...
1818−04...	38±10	...	...	...	...
1929+10...	15± 3	100±55	160±55	85±55	64± 3
1933+16...	81± 5	140±20	20±20	135±20	130±20
2016+28...	122± 5	100±50	160±50	...	...
2021+51...	15± 5	35±30	90±30	25±30	2± 5
2045−16...	14±10	165±25	50±25	145±25	0± 5
2111+46...	112±10	120±75	165±75	...	...
2217+47...	90± 8	90±60	125±60	...	...

session. The intrinsic angle ϕ_I, obtained by extrapolation, and the same angle in galactic coordinates, ϕ_G, are given in Table 2.

The intrinsic angle is considered to be the position angle at which all frequencies are emitted from the pulsar. This interpretation is based on the close linear dependence of observed position angle on inverse squared frequency. Over the frequency range of the present observations this relation was always accurately obeyed. The difference between measured position angles and those calculated by using ϕ_{410} and RM was generally less than 10°, within the expected error of the angles. Further evidence that the position angle is accurately proportional to $1/f^2$ is given in Table 2 where observed position angles at 1665 MHz (Manchester 1971*a*), corrected for ionospheric rotation, are compared with values obtained by extrapolation from the present data. In all but two cases there is agreement within the combined errors, and in these two the discrepancy is only slightly larger.

III. COMPARISON WITH PREVIOUS OBSERVATIONS

Dispersion measures given in Table 1 are generally in good agreement with previously published values, except for a few cases where the only previous measurement was that given in the discovery paper. Measurements with comparable accuracy for pulsars in Table 1 have been made by Goldstein and James (1969) and Davies and Large (1970). Of the 10 pulsars common to the list of Goldstein and James, only three, PSR 1133+16, PSR 1237+25, and PSR 2045−16, differ by more than the combined errors. PSR 1133+16 and PSR 2045−16 agree within twice, and PSR 1237+25 within three times, the quoted errors. Davies and Large give dispersion measures for two of the pulsars in Table 1 which are in good agreement with the present observations.

As these previous measurements were made at an earlier date, the generally good agreement shows that the dispersion measures have not varied significantly with time. Also, Goldstein and James made their observations in a much lower frequency range (112.5–170 MHz), showing that the dispersion law is accurately obeyed over a wide range of frequency. The discrepancies observed may result from a time or frequency dependence of the dispersion measure in these pulsars; however, they are only marginally significant.

Previous rotation-measure determinations for pulsars are listed in Table 3. Where more than one observation has been published for a particular pulsar, usually only the most accurate value is listed. In most cases there is reasonable agreement between values in Table 3 and those in Table 1. The early measurement for PSR 0950+08 by Smith (1968*a*) is not valid, since no allowance was made for frequency structure in the pulsar spectrum resulting from effects other than Faraday rotation (scintillation). The reason for other discrepancies, mainly with values quoted by Lyne *et al.* (1971), is not clear. Observed position angles for some of the weakly polarized pulsars—e.g., PSR 0818−13 or PSR 1933+16—could be affected by instrumental effects such as an error in calibration. A serious error of this type would result in the same position angle being observed at different frequencies, and hence zero or small rotation measure. However, this is not thought to be the reason for the small rotation measures observed for these pulsars, because consistent data were obtained in different observing sessions. Also, stronger but still weakly polarized pulsars—e.g., PSR 1642−03 and PSR 2016+28—did not show this effect. For PSR 1933+16 there is also good agreement between the extrapolated and observed position angle at 1665 MHz.

IV. DISCUSSION

Interpretations of observations of Faraday rotation of extragalactic sources are complicated by the possibility that some of the observed rotation may occur within the source. This is suggested by observations of widely disparate rotations for objects only a few degrees apart—for example, RM = −50 for PKS 1730−13 and RM = +58 for PKS 1732−09 (Gardner *et al.* 1969). Also, observations of large rotation measures for objects at relatively high galactic latitudes—for example, RM = +240 for CTA 21 (Berge and Seielstad 1969) at galactic latitude −34° (also close to two sources with small negative rotation measure)—are difficult to explain.

TABLE 3

PREVIOUS ROTATION-MEASURE DETERMINATIONS

PSR	RM (rad m^{-2})	$\langle B_{l,e} \rangle$ (microgauss)	Reference
0329+54.......	− 95 ±14	−3.5	Smith (1968*b*)
0329+54.......	63 ± 5*	2.9	Staelin and Reifenstein (1969)
0525+21.......	− 39.6± 0.2	−0.961	Manchester (1971*b*)
0531+21.......	− 42.2± 0.6	−0.92	Manchester (1971*c*)
0628−28.......	45*	1.6	Vitkevich and Shitov (1970)
0628−28.......	+ 47 ± 2	+1.6	Schwarz and Morris (1971)
0833−45.......	+ 33.6± 0.1	+0.59	Komesaroff *et al.* (1971)
0834+06.......	+ 26 ± 5	+2.3	Schwarz and Morris (1971)
0950+08.......	< 0.5	<0.2	Smith (1968*a*)
0950+08.......	+ 2 ± 2	+1	Schwarz and Morris (1971)
1508+55.......	+ 40 ±30	+2.4	Lyne *et al.* (1971)
1642−03.......	+ 48 ±10	+1.6	Lyne *et al.* (1971)
1929+10.......	≤ 4	≤1.4	Lyne *et al.* (1971)
1933+16.......	− 36 ±10	−0.3	Lyne *et al.* (1971)
2016+28.......	− 30 ± 5	−2.0	Smith (1968*b*)
2111+46.......	−182 ±20	−2.2	Lyne *et al.* (1971)
2217+47.......	33 ± 3*	0.95	Shitov (1971)

* Magnitude only determined.

Lotova (1970) has suggested that considerable Faraday rotation could occur in the pulsar vicinity. The observations indicate, however, that there is no Faraday rotation intrinsic to pulsars and that all of the observed rotation occurs in the interstellar medium. First, the form of position-angle variation across the pulse is independent of frequency (Radhakrishnan and Cooke 1969; Manchester 1971*a*), showing that there is no differential rotation across the pulse (i.e., across the source). Second, the observation of very small rotation measures for pulsars at high galactic latitudes, particularly PSR 1237+25 (Table 1), makes it very unlikely that there is a significant pulsar contribution to the rotation measure. Third, as will be discussed further below, there is a high degree of order in the galactic distribution of pulsar rotation measures. The observation of very similar mean magnetic fields in the directions of PSR 0525+21 and PSR 0531+21 (Manchester 1971*c*) also supports this conclusion. As strong magnetic fields almost certainly exist in pulsars, this result shows that there must be no large concentrations of thermal electrons in their neighborhood. In view of the efficiency of pulsars as particle accelerators (e.g., Goldreich and Julian 1969) this conclusion is not too surprising.

In magnetic-pole models for pulsars (Radhakrishnan and Cooke 1969; Wampler, Scargle, and Miller 1969) the intrinsic angle at the center of symmetry of the position-angle curve is equal to the projected angle of the pulsar rotation axis. There appears to be no systematic dependence of the angles ϕ_G (Table 2) on galactic position.

In their model associating the pulsars PSR 0525+21 and PSR 0531+21 as runaway members of a binary system, Gott, Gunn, and Ostriker (1970) predict that the rotation axes for these pulsars should be parallel and close to position angle zero. The intrinsic angle for PSR 0525+21 given in Table 2 is $40° \pm 10°$. If the model for PSR 0531+21 proposed by Manchester (1971*c*) is accepted, then 90° must be added to the quoted intrinsic angle to give the projected angle of the rotation axis in this pulsar. This gives a position angle of $55° \pm 20°$ for the rotation axis, which is almost parallel to that for PSR 0525+21, but some distance from 0°.

In Figure 1 the magnitude of the mean magnetic field in the path is plotted against dispersion measure for pulsars in Table 1. Different symbols are used for high- and low-

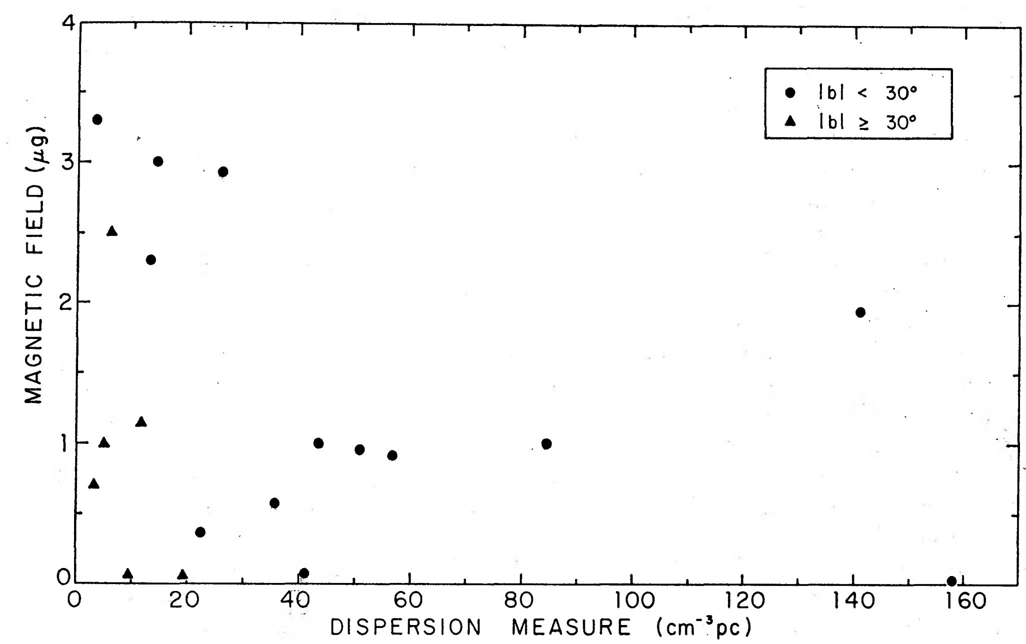

FIG. 1.—Magnitude of the mean line-of-sight component of the magnetic field in the direction of pulsars plotted against dispersion measure with different symbols for high- and low-latitude pulsars.

latitude pulsars. This figure shows that low-dispersion pulsars at high latitudes have weak line-of-sight field components, whereas for those at low latitudes the field component is much stronger, with a maximum observed value of 3.3 microgauss. Low-dispersion pulsars, especially those at low latitudes, are likely to be at small distances. (The converse, that high-dispersion pulsars are at large distances, is not necessarily true). Prentice and ter Haar (1969) give distances of 150 and 300 pc for PSR 1929+10 and PSR 2016+28, respectively. These observations therefore indicate a magnetic field approximately parallel to the galactic plane in the local region. The similarity in derived field strength for PSR 1929+10 and PSR 2016+28 suggests that these measurements give the average interstellar field. As will be discussed further below, the line of sight to these two pulsars appears to be in the general direction of the local field, and they have the largest observed field strengths. We therefore adopt 3.5 ± 0.5 microgauss for the average local field strength—the quoted error is simply an estimate of the uncertainty in this value. Taking this value as the average local field implies that correlated fluctuations in electron density and magnetic field strength are not significant in this region. If the correlation length for magnetic-field fluctuations is as large as 250 pc, as suggested by Jokipii and Lerche (1969), then the field in the local region would be relatively uniform and the derived field strengths would equal the average value. A field strength of about 3.5 microgauss is consistent with that derived from considerations of cosmic-ray pressure (Parker 1969).

It can be seen in Figure 1 that, for low-latitude pulsars, those with larger dispersions generally have weaker field components. This is illustrated by the contrast in observed field strengths for PSR 1929+10 and the nearby high-dispersion pulsar PSR 1933+16. There are several possible explanations for this. These pulsars may be at large distances, and the field may vary in magnitude or direction along the path. This variation may be random as suggested by Jokipii and Lerche (1969), or it may be more systematic.

If 3.5 microgauss is assumed to be a typical field strength, then the energy density of the magnetic field is much less than that associated with large-scale galactic motions. One would therefore expect the field to be elongated in an azimuthal direction because of differential galactic rotation. Also, if density waves are responsible for spiral arms as suggested by Lin and Shu (1964) and others, then magnetic fields would tend to be stronger in the spiral arms where the particle density is greater and correspondingly weaker in the interarm regions.

Prentice and ter Haar (1969) give a distance of 2–4 kpc for PSR 1933+16. Therefore, most of the path to this pulsar lies in the interarm region between the local or Orion arm and the Sagittarius arm, whereas PSR 1929+10 is close and probably within the local arm. The small field component observed for PSR 1933+16 is therefore consistent with a much weaker or perhaps even reversed field in the interarm region. For PSR 2111+46 the observed field component is quite strong (1.95 microgauss) despite its large dispersion measure. This may be accounted for by the fact that the path to this pulsar lies through the local arm and not in an interarm region.

Another possible explanation for smaller field components in high-dispersion pulsars is that the path to the pulsar may pass through an H II region. Reduced and distorted fields would result from expansion of an H II region containing a frozen-in field.

In Figure 2 the observed field strengths have been plotted in galactic coordinates. The two pulsars from Table 3 not in Table 1 (PSR 0628−28 and PSR 0833−45) are also included in this figure, which clearly indicates a well-ordered galactic field. If we neglect three of the pulsars having observed field strengths less than 0.1 microgauss, then all pulsars between $l = 30°$ and $l = 210°$ have field components directed away from the Sun, whereas all those in the other hemisphere have field components toward the Sun. This figure also shows that the largest magnetic fields occur near the galactic plane. There is no indication that the sign of the field differs above and below the plane.

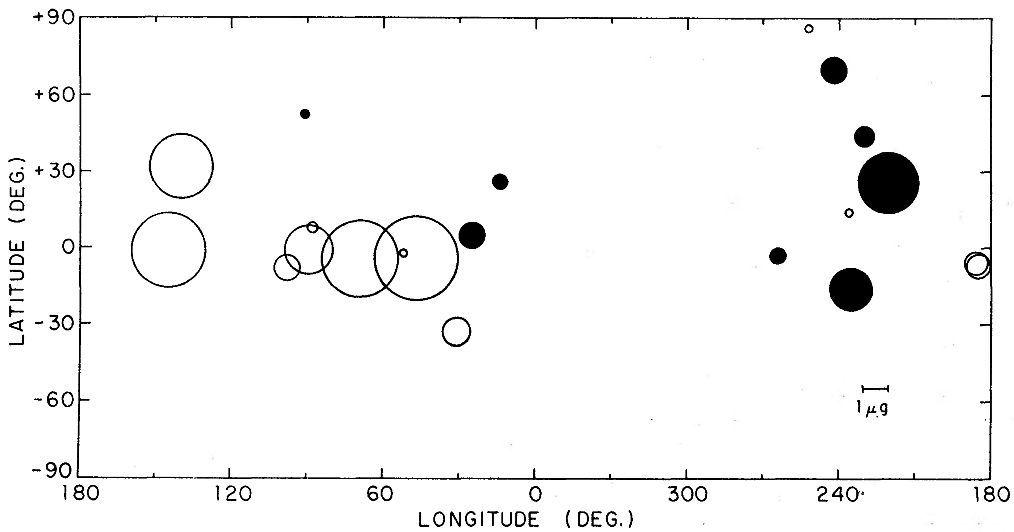

FIG. 2.—Mean line-of-sight magnetic field components for pulsars plotted in galactic coordinates. For fields greater than 0.3 microgauss the circle diamter is proportional to the field strength; for positive rotation measures (field toward the observer) the circles are filled, whereas for negative rotation measures (field away from the observer) they are open. The diameter for a 1-microgauss field is indicated in the figure.

The observations presented here are clearly consistent with a longitudinal field of about 3.5 microgauss directed toward about $l = 90°$ in the local region. They appear to be inconsistent with Mathewson's helical model. Mathewson and Nicholls (1968) give a contour map for the parallel component of the helical field in galactic coordinates, which shows weak field components in the region $l = 0°–180°$. PSR 1929+10 and PSR 2016+28, both in this longitude range and nearby pulsars, have strong field components. Mathewson's model also indicates strong fields of opposite sign above and below the plane in the region $l = 180°–270°$. PSR 0628−28 and PSR 0834+06 are on opposite sides of the plane at intermediate latitudes, are both nearby objects, and have the same sign of rotation measure. Mathewson and Nicholls (1968) have added a longitudinal field directed toward $l = 90°$ to the local helical field to account for the distribution of rotation measures of extragalactic sources, but it is not clear that they intend this field to be present in the local region. If it is present, then it would alter the projected direction of the field in their model and presumably change the parameters of the helices.

The two pulsars with positive rotation measures near $l = 20°$ are in the same region as a group of extragalactic sources with positive rotation measure (Gardner *et al.* 1969). These authors propose a local deformation, perhaps associated with the North Polar Spur, in an otherwise uniform field directed toward $l = 80°$ to account for their observations. The present results are essentially consistent with this model.

Observations of Faraday rotation for pulsars clearly are of considerable value in investigating the galactic magnetic field. Further measurements, particularly in the longitude range 240°–360°, would be very useful in further defining the local field structure.

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