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High accuracy measurements of the interstellar magnetic field in the direction of pulsars with a new method

T.V. Smirnova[1] **and V. Boriakoff**[2,3]

[1] Astro Space Center of the Lebedev Physics Institute, Russian Academy of Sciences, Profsoyuznaia ul. 84/32, 117810 Moscow, Russia
[2] National Research Council, Washington DC, USA
[3] Geophysics Directorate, GPSG, Phillips Lab, Hanscom AFB, MA, 01731, USA (boriakof@amenra.plh.af.mil)

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Abstract. Low error measurements at the Arecibo Observatory (at 318MHz) of the weighted average interstellar magnetic field projected on the line of sight $\langle B_{\|} \rangle$ and of the Rotation Measure in the direction of several pulsars were done using a new method. This method is based on the measurement of the period of the temporal modulation in the linearly polarized component of the pulsar pulse observed in a wide receiver bandpass. The error in the measurement of $\langle B_{\|} \rangle$ and RM is about one order of magnitude smaller than previously published measurements. Because of its high accuracy this method will continue to be used for the monitoring of the interstellar magnetic field in the directions to pulsars.

Key words: ISM: magnetic field – pulsars: general – Methods: observational – polarization – Instrumentation: polarimeters

1. Introduction

The study of the interstellar magnetic field has great interest for the understanding of the physical processes involved in the evolution and structure of the interstellar medium. Pulsars are powerful instruments for such studies, since they have highly linearly polarized radioemission which, when propagating through the magnetoactive interstellar medium, experiences a rotation of the plane of linear polarization – the well known Faraday effect. This rotation is the physical foundation for the measurement of the average magnetic field projected in the direction of pulsars $\langle B_{\|} \rangle$. In this work we use a new method for the measurement of $\langle B_{\|} \rangle$ (Smirnova 1991) which is based on the measurement of the period of the temporal modulation of pulsar radioemission observed in the wide bandpass of a receiver. This method has a higher accuracy than the standard method, and is experimentally much simpler.

The main purpose of this work consists of the high accuracy measurement of $\langle B_{\|} \rangle$ in the direction of pulsars, and, in a following study, the monitoring of its time variations. Since pulsars are fast moving objects ($v \simeq$ hundreds of km/sec) we may be able to detect small-scale variations by monitoring $\langle B_{\|} \rangle$ in a reasonably short span of time. This may be particularly true for pulsars associated with SNR's, where in the interface of the expanding shock wave and the interstellar medium we should expect such variations. Except for the SNR's surrounding the Crab and Vela pulsars no monitoring of this type was done up to now. However, there are measurements of extragalactic sources located behind SNR's (e.g. Kim et al. 1988) which show a substantially larger RM than that of nearby background sources. For PSR 0531+21 (Crab) and PSR 0833−45 (Vela), both inside SNR's, a change of the RM with time was noted (Rankin et al. 1988, Hamilton et al. 1977), in both cases these changes were attributed to the environment local to the pulsar, not to the interstellar medium.

Send offprint requests to: V. Boriakoff (Phillips Lab)

2. Method, observations, and data reduction

We observed with a standard radioastronomy receiver of wide frequency bandpass: a linearly polarized antenna, a receiver followed by a detector, time constant, and a recording system. No polarimeter and no dedispersion system were used, and no calibration (except for the ionosphere) was necessary. We recorded individual pulsar pulses, for our purpose these pulses should have a strong linearly polarized component. As these pulses drift downwards in frequency through the bandpass following the delay in arrival time (due to the cold interstellar plasma dispersion law) they will experience a rotation of the plane of polarization (Faraday effect) (Fig. 1). It is very common to have a pulsar pulse with a variable linearly polarized component, and where the (intrinsic) sky angle of the direction of the linear polarization is variable through the pulse (e.g. Rankin & Benson 1981, Stinebring et al. 1984, Rankin et al. 1989). Nevertheless, the signal component within a pulse which has the maximum linearly polarized flux has a well defined polarization direction in many pulsars, and we will take this to be the dominant linear polarization angle. The intrinsic sky angle of polarization at source ψ_{intr} is taken to be constant over the receiver bandpass at any given pulse longitude, including that of the dominant linear polarization. After propagation through the interstellar medium the direction of this dominant linearly polarized electric field vector rotates as a function of frequency. If observed with an antenna-receiver system that measures full intensity (e.g. two cross-polarized antennas with a receiver each, both detected outputs summed together) followed by our backend and recording system we will simply see a dispersed pulse (Fig. 1b). If instead we use a single linearly-polarized antenna-receiver system that receives a signal with a linearly-polarized component whose electric vector rotates as a function of frequency (Fig. 1c), then the voltage induced in the linearly-polarized antenna is the dot product of the electric vector and a unit vector in the direction of the antenna polarization. As a function of time within the dispersed pulse this will result in a sine wave: the electric vector either aligns itself with the linearly-polarized antenna at certain frequencies, where we will have the maximum of the sine, or is perpendicular to it at others, where we will have the minimum of the sine, or, for in-between frequencies, we will have the sine projection values. All other pulse components (circularly polarized, non-polarized, etc.) will also be received by this linearly-polarized antenna-receiver system, and will be the non-polarized component of the pulse, as shown in Fig. 1.

The time delay τ_{disp} (sec) of the arrival of a pulse at the frequency f (MHz) from the arrival at $f = \infty$ due to interstellar medium dispersion is

$$\tau_{disp} = \frac{DM}{K}\left(\frac{1}{f^2}\right)$$

where $K = 2.41 \times 10^{-4}$ pc · cm^{-3} · sec^{-1} · MHz^{-2} and DM is the dispersion measure, pc·cm^{-3}. The angle of rotation (rad) of the plane of linear polarization at the frequency f from the intrinsic sky angle ψ_{intr} due to Faraday rotation is

$$\psi - \psi_{intr} = RM \cdot \lambda^2 = RM \frac{c^2}{f^2}$$

where the rotation measure RM (rad · m^{-2}) is

$$RM = A \int_0^R n_e B \cos\theta \, dl =$$

$$= A \cdot \langle B_{\|} \rangle \int_0^R n_e \, dl = A \cdot \langle B_{\|} \rangle \cdot DM \qquad (1)$$

where $A = 0.81 \cdot \text{rad} \cdot \text{m}^{-2} \cdot \mu\text{Gauss}^{-1} \cdot \text{pc}^{-1} \cdot \text{cm}^3$, R is the distance pulsar – observer, $\langle B_{\|} \rangle$ in μGauss, and $RM > 0$ if the magnetic field is pointed towards the observer. Consider two frequencies: f_1 and f_2, between which the electric field vector (or the plane of the dominant polarization) executes one half of a full turn (π) (that is, sinusoid maximum to maximum, one full period)

$$\psi_1 - \psi_2 = \pi = RM \cdot c^2 \left(\frac{1}{f_1^2} - \frac{1}{f_2^2}\right) \qquad (2)$$

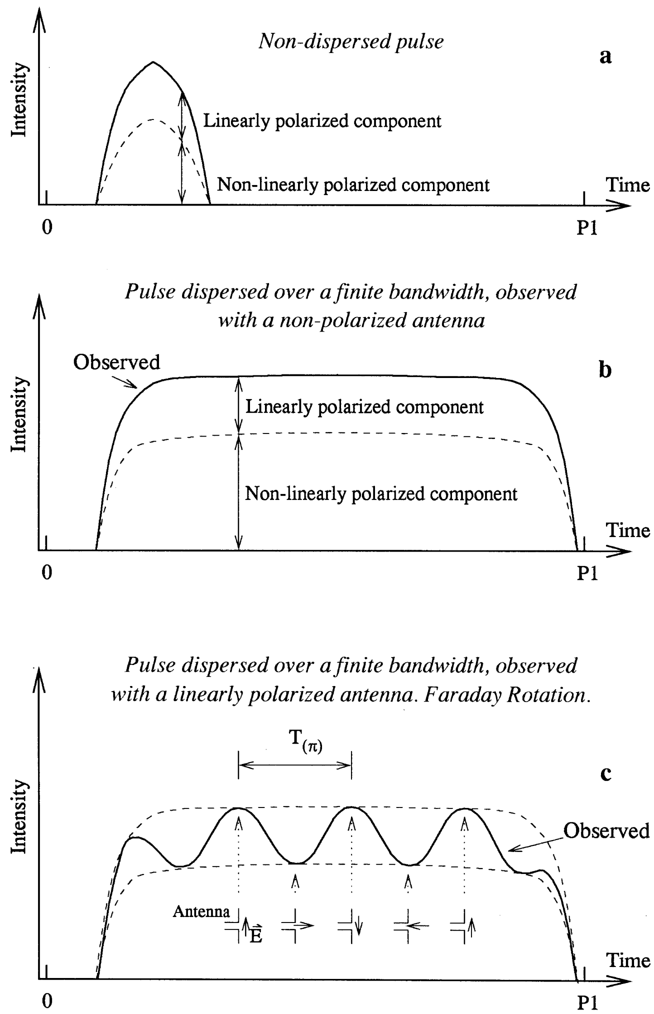

Fig. 1a–c. Cartoon representation of the output of the pulsar pulse when observed with three different receiver systems. **a** Single pulse as observed with a narrowband filter (not dispersed), or at source (intrinsic). **b** Dispersed pulse at the output of our wideband receiver system, if we observe intensity (non-polarized system). Amount of linear polarization contribution is indicated. **c** Same as **b** but observed with a linearly polarized antenna. Alignment of the dominant linearly polarized electric vector **E** and the antenna dipole is indicated at different frequencies (times) as the dispersed pulse descends in frequency within the passband.

Between f_1 and f_2 there is a dispersion delay $T_{(\pi)}$

$$T_{(\pi)} = \frac{DM}{K}\left(\frac{1}{f_1^2} - \frac{1}{f_2^2}\right) \qquad (3)$$

Hence, for one π turn of the polarization plane there is a delay that we obtain from Eq. (2) and (3) (Smirnova 1991) (after replacing constants)

$$T_{(\pi)}(\text{msec}) = \frac{178.7}{\langle B_{\|} \rangle (\mu\text{Gauss})} \qquad (4)$$

Note that $T_{(\pi)}$ depends exclusively on $\langle B_{\|} \rangle$ here, and will be constant through the bandpass. $T_{(\pi)}$ is a constant in the temporal domain, that is $T_{(\pi)}$ is the same at all receiver frequencies.

$T_{(\pi)}$ does not depend on the sign of RM or $\langle B_{\|}\rangle$, hence it tells us their absolute value, however, it is possible to determine indirectly the sign for new measurements (see below). The detected output of our wideband receiver shows the pulsar pulse as wide pulses, smeared by dispersion over the bandpass (Fig. 1a and b). With a linearly-polarized antenna-receiver system within these widened pulses we will see the sine modulation of period $T_{(\pi)}$ as the dominant linearly-polarized component of the pulsar pulse changes its angle continuously with respect to the direction of polarization of the antenna (Fig. 1c). That ψ_{int} remains constant throughout the BW is a good assumption, since we select $BW \ll f_c$, where f_c is the center receiver frequency. We emphasize that, having eliminated the $1/f^2$ dependence in the measured parameter $T_{(\pi)}$, the *primary* parameter measured with our method is the magnetic field $\langle B_{\|}\rangle$ (Eq. (4)), which is of physical interest, and has errors due only to our measurement of $T_{(\pi)}$ and reduction procedures. The RM is a *derived* parameter in our experiment, and includes the errors of the DM measurements done separately.

We chose the observation frequency and the bandpass so that we have a dispersion delay over the bandpass τ_{BW} as large as possible, so the number of rotations of the electric vector would be as large as possible. But it must be $\tau_{BW} < P_1$, where P_1 is the pulsar period, so that consecutive pulses do not overlap. BW should also be consistent with the receiver (and interference!) constraints. For a proper fitting we need a minimum of two or three sine cycles (better more), that is BW should be larger than $2 \cdot (f_2 - f_1)$ or $3 \cdot (f_2 - f_1)$, depending in part on the signal-to-noise ratio. If these conditions are not met a different receiver frequency may solve the problem.

For observation we have selected mostly pulsars of a tabulated average flux $S > 15$mJy at 400MHz, however, because of signal variability some pulsars weaker than this limit produced good results, and some pulsars stronger than this limit produced poor or no results. If polarization characteristics were known high linear polarization pulsars were preferred.

Observations were carried out in August – September, 1992, at Arecibo. Strong interference at the preferred 130MHz band precluded observations. At 318MHz seven pulsars turned out to be too weak, and two others (PSR 1845−01 and PSR 1900+06) had no sinusoidal modulation superimposed, presumably because of a low linear polarization component. Positive results were obtained for seven pulsars, all at 318MHz. Table 1 lists them, the bandwidth BW used, their dispersion smearing τ_{BW} and period P_1.

The detected output of the receiver (integrated by a 2 msec time constant) was sampled with an A/D converter with a period of of 0.5 msec, and continuous 15-minute recordings on tape were done, n recordings per pulsar (Table 1). Then the time average of the dispersion-smeared pulse profile was obtained by folding the data with a period P_1, where 512 bins were distributed. No pulse selection was done. Since the beginning of the integration had an arbitrary pulse phase we normally rotated cyclically the integrated pulse so that the beginning of the pulse corresponded to the low order bins. A running average smoothing of N consecutive points (Table 1) was done to improve the signal-to-noise ratio. To obtain the period of the sine a least-squares fitting of the sum of a sine and a second degree polynomial was done, and the sine frequency, phase and amplitude, the three polynomial coefficients, and their errors were obtained from the fit. Using higher degree polynomials did not improve the fit. Of the fitted parameters only the frequency of the sine is of interest. As the modulated part of the dispersed pulse was less than P_1 only the part of the pulse period with sinusoidal modulation was used in the fitting procedure.

Table 1. Pulsars observed at 318 MHz and their parameters: P_1, pulsar period; BW, observational bandwidth; τ_{BW}, dispersion delay over the observational bandwidth; N, number of points of running average; n, number of 15-minute observations used in the processing.

Pulsar PSR B	P_1 (sec)	BW (MHz)	τ_{BW} (sec)	N	n
0611+22	0.335	10	0.250	20	9
1737+13	0.803	20	0.252	5	2
1859+03	0.655	5	0.624	30	4
1907+10	0.284	5	0.186	10	5
1915+13	0.195	5	0.121	10	4
1946+35	0.717	20	0.666	5	1
2000+32	0.697	10	0.348	40	1

Different parts of the pulse may have linear polarization components that have different polarization sky angles. Each will produce sines of the same frequency but different phase. Because the sum of sines of constant frequency (which depends only on $\langle B_{\|}\rangle$) but arbitrary phase is also a sine of the same frequency, we do not have to separate the contributions from different pulse longitudes. In many pulsars the polarization angle swings over the whole pulse longitudes range (e.g. Rankin & Benson 1981) is of the order of $\pi/2$ or less, the resulting sine will be of larger amplitude than the original sines. Fitting to the resulting sine produces the same result (frequency) as fitting to separate pulse component sines. Nevertheless, in most cases one component at a specific pulse longitude predominated.

The signal inside the receiver goes through a square-law detector, however, the reasoning developed above is valid for the voltage induced by the electric field in the antenna, not the power. The voltage sinusoid that we obtain in this experiment after going through the square-law detector becomes the sum of a sine and double frequency cosine. The contribution of the double-frequency cosine term is small, and it becomes significant only if the pulse linear polarization component approaches 100%, not common in pulsars. In any case double-frequency distortion adds little to the error in the fitting procedure, where we are primarily interested in the frequency of the sine.

3. Results

In Figs. 2 and 3 we show examples of the processing for three pulsars. With a solid line we show the averaged dispersed and

Table 2. Pulsars observed at 318 MHz and their known and newly measured parameters: DM, Dispersion Measure and error, Taylor *et al* 1993; T_π, period of sine modulation and error; $|\langle B_\parallel \rangle|$, our value for the weighted average of the magnetic field projected on the line of sight and error; $|RM|$, our value of the absolute value of the Rotation Measure and error; RM, HL Rotation Measure and error, Hamilton and Lyne 1987; RM, H Rotation Measure and error, Hamilton *et al* 1981. Note that our measurements of $\langle B_\parallel \rangle$ and RM have no sign, so their absolute value is listed here.

Pulsar PSR B	DM (pc.cm^{-3})	T (msec)	$\|\langle B_\parallel \rangle\|$ (μgauss)	$\|RM\|$ (rad.m^{-2})	RM, HL (rad.m^{-2})	RM, H (rad.m^{-2})
0611+22	96.7 ±0.05	176. ±1.	1.015 ±0.005	79.7 ±0.5	62 ±5	67. ±7.
1737+13	48.9 ±0.3	102.6 ±7.8	1.74 ±0.14	69.4 ±5.5	73 ±5	...
1859+03	402.9 ±0.9	249.2 ±0.7	0.717 ±0.002	234.7 ±1.	−242 ±12	−237.4 ±15.
1907+10	148.4 ±0.3	39.07 ±0.05	4.577 ±0.005	551. ±1.3	540 ±20	...
1915+13	94.8 ±0.2	60.35 ±0.15	2.961 ±0.008	227.0 ±0.8	233 ±8	264. ±21.
1946+35	129.05 ±0.04	168.1 ±0.6	1.063 ±0.004	111.3 ±0.4	116 ±6	...
2000+32	134. ±6.	211.5 ±2.5	0.845 ±0.010	92. ±4.5	...	...

Faraday-modulated pulse profile, with an N point running average applied. The fitted sine plus polynomial are shown as a dotted line. In the Fig. 2 example of PSR 1907+10 we have in the 5MHz bandpass full six periods of the Faraday rotation modulation, and their period $T_{(\pi)}$ is remarkably close for observations at different days, within 1σ. This error constitutes 0.13% of a single measurement of $T_{(\pi)}$. Since we directly measure $T_{(\pi)}$ we can obtain the Rotation Measure RM from Eq. (2) and (3) (e.g. Smirnova 1991) as

$$RM(\text{rad.m}^{-2}) = \frac{145.042 \cdot DM(\text{pc.cm}^{-3})}{T_{(\pi)}(\text{msec})}$$

where tabulated DM values were used (Taylor et al. 1993). In Table 2 we list the DM used, the RM values measured before our work (Hamilton & Lyne 1987 (HL), and Hamilton et al. 1981 (H)) and their errors. We also list our values (and errors): $T_{(\pi)}$, the absolute values of $|\langle B_\parallel \rangle|$, and of $|RM|$. The unweighted average was used when we had more than one observation of a pulsar. The errors in $\langle B_\parallel \rangle$ were obtained from the fitting procedure after the effect of the ionosphere was removed, and depend to a large extent on the signal-to-noise ratio. The errors in RM include the error in T and the published error value of DM (Table 2) (Taylor et al. 1993). To be noted is the DM errors may be the dominant source of error in the value of RM for some cases. For example, for PSR 1907+10 if the error of the DM would be 5 times smaller the error in RM would be nearly halved. Another source of error is the time variation of DM, which could have a different value due to different observing epochs (e.g. Phillips & Wolszczan 1991). In our method we measure the actual $\langle B_\parallel \rangle$, regardless of what the DM is at the time.

The ionosphere also contributes to the rotation of the plane of polarization; the high accuracy of our measurements requires that it must be accounted for. An electromagnetic wave traversing two magnetoactive plasmas successively (interstellar medium and ionosphere) will have an RM_{obs} that is the algebraic addition of the two RM's of the two plasmas RM_{obs} = RM + RM_i. Hence, if the ionospheric RM_i is known we can obtain the interstellar medium RM. After replacing constants and assuming a constant magnetic field through the ionosphere the RM_i is (a variant of Eq. (1))

$$RM_i(\text{rad/m}^2) = 2.64 \times 10^{-13} n_t(\text{cm}^{-2}) \cdot B_{\parallel i}(\text{Gauss})$$

where $B_{\parallel i}$ is the projection of the average magnetic field at the ionosphere along the line of sight to the pulsar, for Arecibo a value of $|B_i|$ = 0.38 Gauss with a direction 50° from the horizontal plane and 9° West of geographic North was used. The ionosphere is thin (200-300 km), over it the Earth's magnetic field varies very little, so that a constant value of B_i is more than adequate for this correction. n_t is the ionospheric total electron content along the line of sight to the pulsar, typically during our observations n_t = 1 × 10^{13} to 3 × 10^{13} cm^{-2}.

To determine n_t for each case we measured the ionospheric vertical $f_O F2$ value with the help of an ionosonde at the end of each observation run, and calibrated $f_O F2$ with on-site incoherent scattering ionospheric radar observations. They show that n_t (as measured vertically) may vary day to day and hour to hour, by up to 10^{13} cm^{-2}. Variations of n_t over the 15-minute observation span may reach 0.2×10^{13} cm^{-2}. The period $T_{(\pi)}$ of

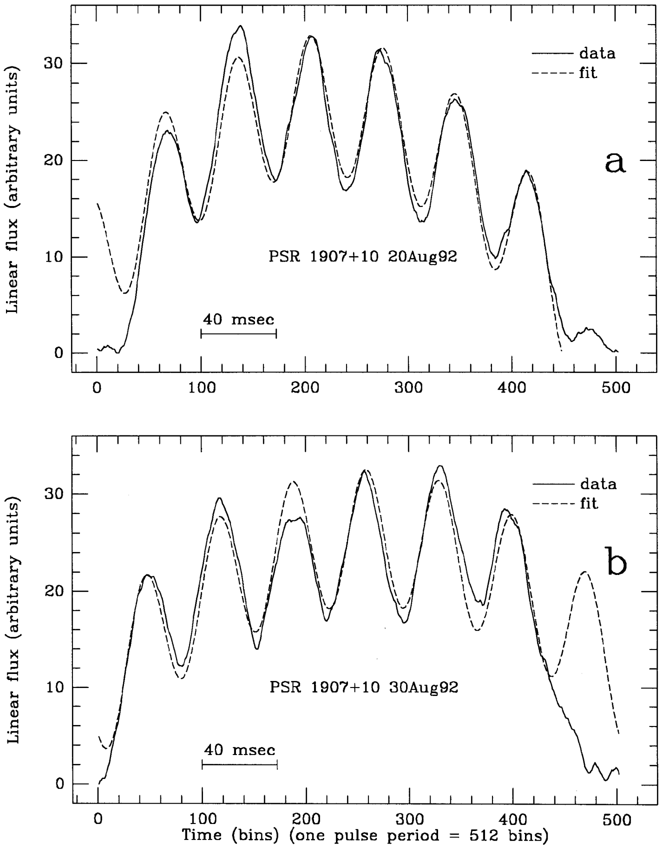

Fig. 2a and b. Averaged dispersed pulse profile for PSR 1907+10 as observed with our system for two different observing days (solid lines) smoothed out with a 10-point running average. Least-squares fitting of the sum of two functions (a sine and a 2-nd degree polynomial) to the original data curves (dashed lines). The horizontal (time) axis has 512 bins for the full pulse period P_1 and the vertical axis represents linear polarization intensity in arbitrary units.

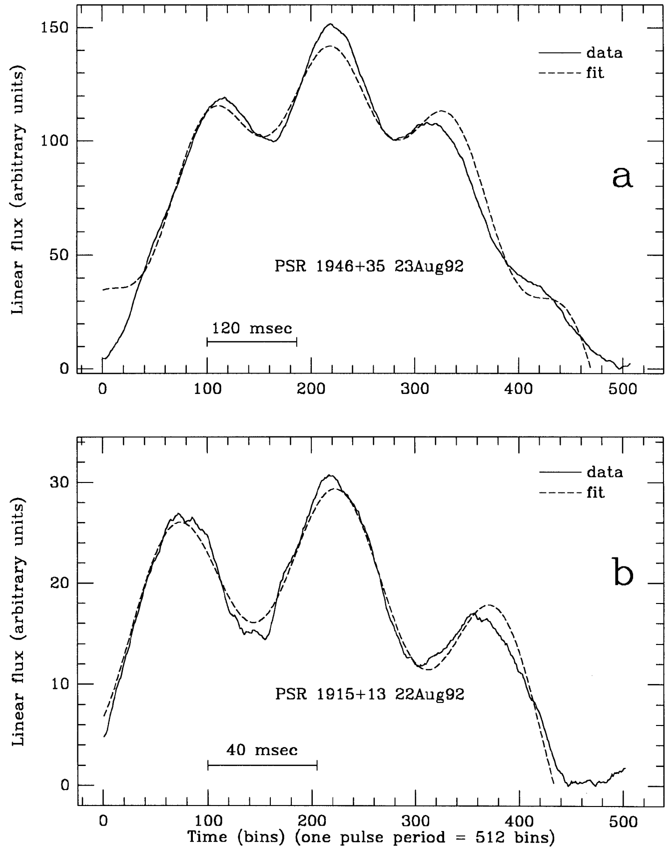

Fig. 3a and b. Same as Fig. 2 for **a** PSR 1915+13 and **b** PSR 1946+35.

the sine modulation corrected for ionospheric effects is

$$T_{(\pi)} = T_{(\pi)obs}\left(1 - \frac{T_{(\pi)obs} \cdot RM_i}{145.042 \cdot DM_{obs}}\right)^{-1}$$

where the sign of RM_i follows the same rule as the interstellar medium RM sign. This correction is based on $DM_{obs} \gg DM_i$, which is always the case. In Table 2 the listed values are corrected for the ionosphere: $T_{(\pi)}$, $|\langle B_{\|}\rangle|$, and $|RM|$, computed from $RM = (RM_{obs} - RM_i)$ before the absolute value was taken. The sign of RM_{obs} is not known from our observations. For those pulsars observed by others we used their sign in computing the ionospheric correction, but we included the full ionospheric correction as an error for PSR 2000+32, where the sign is unknown. For pulsars observed by us, the ionospheric correction to $T_{(\pi)obs}$ ranged from 0.08 to 3 msec, RM_i ranged from 0.8 to 3 rad/m^2. The corrections to $\langle B_{\|}\rangle$ go from 0.003 to 0.015 μGauss. The short-term variations of n_t may give errors in the determination of parameters of the order of $\Delta T_{(\pi)obs} \leq 0.3$ msec, $\Delta RM \leq 0.15$ rad/m^2, and $\Delta\langle B_{\|}\rangle \leq 0.002$ μGauss. The error in a single measurement of RM_i was always better than $0.3 \cdot RM_i$. The influence of these corrections and their errors can be reduced through averaging observations over consecutive days, and through a better knowledge of the ionospheric parameters during the observations.

It is of interest in our method that, even if we do not know the sign of the measured $\langle B_{\|}\rangle$ and RM, the ionospheric correction can provide the sign for some of the newly measured values. Observations done on different days will have different ionospheric contributions RM_i. Since the sign of the ionospheric contribution is known the sign of the interstellar medium contribution can be inferred.

For PSR 1737+13 the experimental setup parameters were not optimal, hence the errors of our values are large, it should be reobserved at lower frequencies. We see that of all the known pulsars PSR 1907+10 has the largest value of $\langle B_{\|}\rangle$ and one of the lowest measurement errors, making it an excellent candidate for long-term monitoring.

4. Comparison with the standard method

The standard method for the measurement of $\langle B_{\|}\rangle$ consists in the determination of the direction for the plane of polarization at a certain pulse longitude at two or a few different frequencies, and consequently obtain RM. From other measurements the Dispersion Measure DM is obtained, and from the ratio of RM and DM the value of $\langle B_{\|}\rangle$ is computed (e.g. Hamilton & Lyne 1987). The errors in $\langle B_{\|}\rangle$ measured with the standard method are not smaller than 5% in the vast majority of cases (e.g. Hamilton & Lyne 1987) with some of the exceptions being the Crab pulsar, 1.2%, and the Vela pulsar, 0.16%. In the standard method, the measurement of the polarization angle at two or three frequencies lends itself to ambiguous values of RM due to possible additional rotations by π between the observing frequencies. In principle the ambiguities could be resolved by observing at three carefully chosen frequencies, however, errors in the measurements require least-square fittings and χ^2 computations to choose the right RM, which sometimes even with this approach will remain indeterminate (e.g. Rand & Lyne 1994). There are no ambiguities in the absolute value of $\langle B_{\|} \rangle$ (and resulting RM) we measure, since we observe the rotation of the electric vector continuously throughout the bandwidth. Although the sign of $\langle B_{\|} \rangle$ is not determined in our method, the ionospheric correction may provide it.

Contrary to our method, in the classical one a careful selection of the pulse longitude range over which the electric vector angle is measured has to be done, otherwise the swing of the polarization angle with pulse longitude may introduce large errors.

When observing in the classical method the rotation of the electric vector in the frequency domain, a sine appears whose frequency is variable and function of the receiver frequency, as can be seen from Eq. (2). Fitting to the frequency-modulated sine to obtain $\langle B_{\|} \rangle$ implies fitting for the DM as well, a disadvantage when compared to our method.

As we see from Table 2 the accuracy in the determination of RM with our method is substantially better than that of previous measurements, in most cases by more than an order of magnitude. We have chosen to compare RM values because they are the primary (directly measured) values for the classical measurement methods, however, they are secondary (resulting from two independent measurements) values for our method and include the error in the DM measurement, which we obtain from tables. Even so, our method has substantially smaller RM errors.

The increase in accuracy in measuring the physically important $\langle B_{\|} \rangle$ with our method is due to two reasons: first to the least squares fitting procedure to a simple sine, where the direction of the plane of polarization is determined at many frequencies simultaneously vs. the standard measurements where it is determined at two or three frequencies only. The second reason is that the primary parameter determined here is $\langle B_{\|} \rangle$, and has the smallest errors (being measured directly), and not RM, which is determined with the help of other DM measurements and includes the errors of both DM and $\langle B_{\|} \rangle$. This is a consequence of the new method, where the contributions of DM cancel in the measurement of $T_{(\pi)}$. By contrast, in the standard method the primary measured parameter is RM, and $\langle B_{\|} \rangle$ is obtained with the help of DM values measured separately, and includes the errors of both RM and DM.

5. Conclusions

We have developed a new approach to measure directly $\langle B_{\|} \rangle$ averaged along the line of sight to pulsars as a primary parameter. Because of the method used the accuracy in the measurement of the physically important $\langle B_{\|} \rangle$ is very high. We can measure μGauss values of $\langle B_{\|} \rangle$ with errors of the order of $\Delta\langle B_{\|} \rangle \approx 5 \times 10^{-9}$Gauss. The measurement can be done in an extremely simple experimental setup suitable for absentee long-term monitoring. By following the variation of $\langle B_{\|} \rangle$ as the line of sight pulsar-observer moves with time we will be able to determine decorrelation distance scales for magnetic field structures, a much more accurate method than using sets of background sources (e.g. Lazio et al. 1990), which, in spite of their angular proximity, may be located at different distances from the observer and have different DMs and RMs. Determination of decorrelation scales is very important for magnetic field model construction, it indicates levels of turbulence and percentages of randomized magnetic fields, both strongly related to dynamics of interstellar matter (e.g. Troland & Heiles 1986). In addition the comparison of magnetic field, ionized and neutral gas components through the use of DM variations and HI absorption in the line of sight towards certain pulsars may provide insight into the distribution of the magnetic field in the interstellar medium. At present it seems that the interstellar medium has a substantially stronger magnetic field in the high density cold HI clouds (Troland & Heiles 1986) and a weaker magnetic field in the rest of the volume.

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