ON THE CASE FOR MAGNETIC FIELD LINE SWEEP-BACK IN PULSARS 0950+08 AND 1133+16

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Abstract

Coordinated profile observations between 25 MHz and 5 GHz have been carried out at the Arecibo and Pushchino observatories, and aligned according to dispersion measure (*DM*) values determined by cross-correlating microstructure features at adjacent frequencies. The average profiles of the nearly aligned rotator PSR 0950+08 align satisfactorily using the *DM* value of 2.9701 pc cm^{-3}. For PSR 1133+16 excess delay at low frequencies is observed when alignment is made using the value of $DM = 4.8413$ pc cm^{-3} determined from microstructure cross-correlations.

Introduction

Over the course of several years average profiles of several pulsars were recorded at both the Arecibo Observatory and the Pushchino Radio Astronomy Station for the purpose of testing the hypothesis of field-line sweep-back at low frequencies. If the height of pulsar emission above the polar cap is a strong function of radio frequency, then one may expect that at low enough frequencies, or at high altitudes, corotation failure of the magnetic field will tend to impose a poloidal component to the magnetic field. The direction of conal emission from curvature radiation will then no longer be concentric with the magnetic axis, as defined by the point at which it emerges from the polar cap. If the conal emission occurs in the direction tangential to the local magnetic field lines, then at high altitudes, the field-line sweep-back will cause the emission to deviate from the radial direction and lag azimuthally behind the high frequency emission.

Observations

We have obtained time-tagged average profiles over a wide range of frequencies, which we have then aligned by reducing the arrival times to the solar system barycenter using the CfA ephemeris and timing models provided by the Princeton pulsar timing group. The 25-MHz profiles were obtained by J. A. Phillips and A. Wolszczan. After correction for bandwidth rise-time and detector integration delay, the only free parameter for time of arrival reduction is the dispersion measure (*DM*). Since a fit to the quadratic dependence of arrival time on frequency due to interstellar dispersion can mask at least one term of any other effect, we chose to align the profiles using *DM* values obtained from precision cross-correlations of pulsar microstructure.

Discussion

It has been well established (Kardeshev *et al.* 1982, Boriakoff 1983, Popov, Smirnova, and Soglasnov 1987) that microstructure does not participate in radius to frequency mapping. Therefore microstructure cross-correlation provides an excellent, independent method for *DM* determination which does not depend upon profile fiducial point matching or template fabrication. We have also conducted our own microstructure cross-correlation measurements and have obtained results that are consistent with the earlier measurements.

PSR 0950+08 has been shown to be consistent with a single-pole interpulsar whose rotation and magnetic axes are nearly aligned. For this star, then we expect little distortion of the polar field

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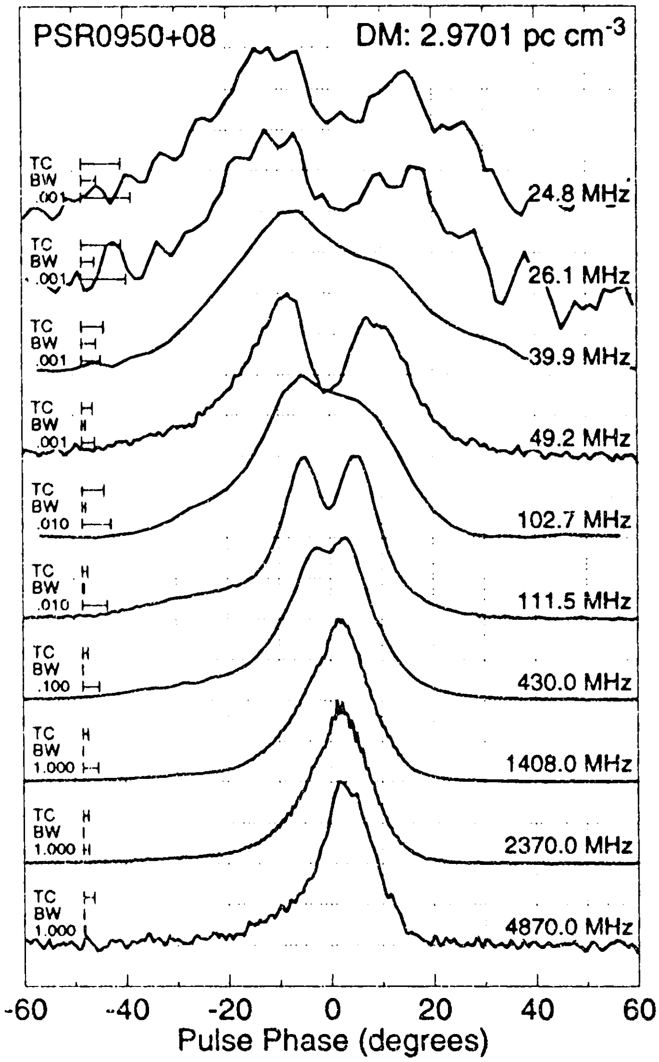

Figure 1 Average profiles for PSR 0950+08 aligned absolutely in time using a dispersion value of 2.9701 pc cm^{-3}. The Arecibo observations in the 4870, 2380, 1400, 430, 111, 49 and 26-MHz bands are total-intensity, whereas the Pushchino measurements at about 102, 60, 40 and 30 MHz represent a single linear polarization. Symbols at the left of the plot indicate the detector time-constant (TC), the dispersion smearing time across the receiver bandwidth (BW), and the third bar shows the time shift at each frequency which would be produced by the given change in *DM* in units of pc cm^{-3}.

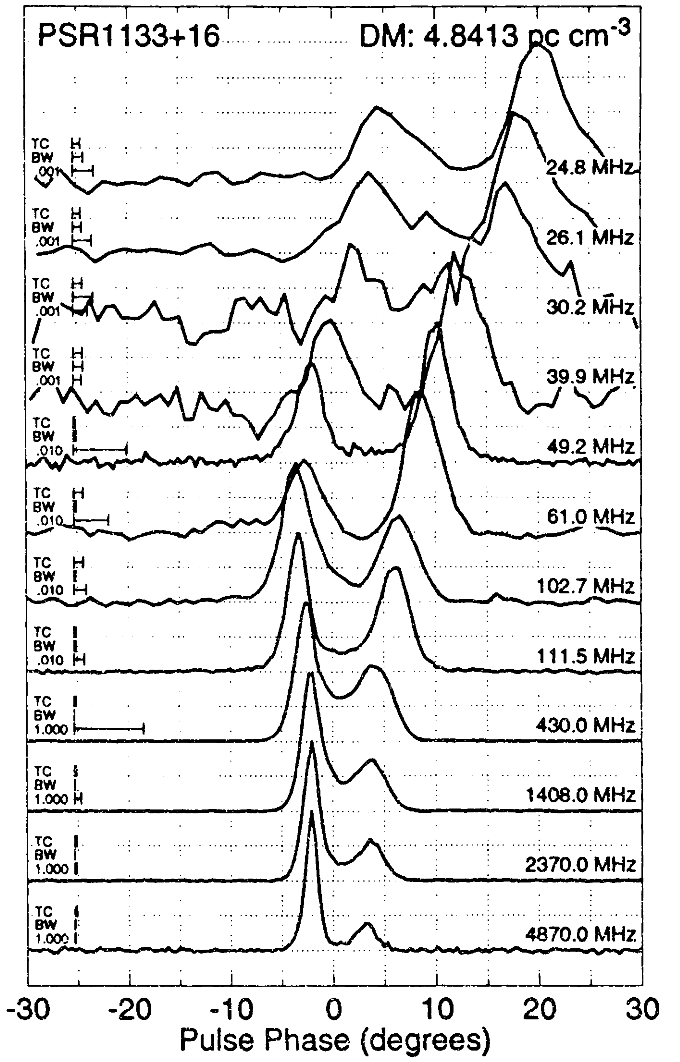

Figure 2 A set of multifrequency profiles for PSR 1133+16 aligned absolutely in time using the microstructure cross-correlation dispersion measure value, DM = 4.8413 pc cm^{-3}.

lines due to corotation failure. Our average profile alignment, shown in figure 1, shows no excess delay at low frequencies. PSR 1133+16 (figure 2), on the other hand, which exhibits strictly core emission over the full 25 to 5000 MHz frequency range, has a much narrower profile, and it is also thought to have a much larger angular spacing between its rotational and magnetic axes (Hankins and Fowler 1982). The low frequency profiles show clear excess delay when aligned with the microstructure cross-correlation value (Kardeshev *et al.* 1982), $DM = 4.8413\,\mathrm{pc\,cm^{-3}}$, and are consistent with the observations and conclusions of Shitov, Malofeev and Izvekova (1988).

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