Pulsars : Problems & Progress
ASP Conference Series, Vol. 105, 1996
S. Johnston, M. A. Walker and M. Bailes, eds.

Phase-referenced VLBA Observations of PSRs B1937+21 and B0329+54

Rachel J. Dewey

Physics Department, Princeton University

Anthony J. Beasley

National Radio Astronomy Observatory

1. Introduction

In this paper we present the preliminary results of phase-referenced VLBA observations of two pulsars PSR B1937+21 and PSR B0329+54. Since pulsar observations usually require a lower observing frequency than that used for other astrometric applications, ionospheric delays are a significant source of systematic error. For the observations presented here we used total-electron-content (TEC) measurements derived from dual-frequency GPS observations (Wilson, Mannucci & Edwards, 1995) to calibrate ionospheric delays.

Using this calibration technique were able to obtain positions for these two pulsars which we believe to be accurate to approximately 2 mas in each coordinate. With this level of accuracy we expect astrometric pulsar observations to be able to address a variety of interesting issues ranging from reference frame alignment and fundamental astrometry to the origin of pulsar velocities.

2. Observations and Analysis

L-band (1.67 GHz) observations were made on 14 April 1995, using all ten VLBA antennas, a 32 MHz bandwidth and 2-bit sampling. PSR B1937+21 and the calibration source 1923+21 were observed for a total of 2.5 hours during the UT range 10:30 - 14:30. PSR B0329+45 and the calibration source 0359+509 were observed for a total of 2 hours during the UT range 17:50 - 24:00.

The data were correlated on the VLBA correlator, without pulsar gating (that capability has not yet been implemented); images were made using AIPS. We developed AIPS routines that allowed us to apply ionosphere calibrations derived from external TEC data. We used TEC data provided by the Jet Propulsion Laboratory which were derived from dual frequency GPS measurements. The data set consisted of a grid of TEC values at one degree intervals of latitude and solar longitude, each covering an hour long interval. In the latitude range of the VLBA, TEC values of a few times $10^{17}\,\mathrm{m}^{-2}$ were typical for daytime, while nighttime values were about an order of magnitude lower.

Images were made both with and without applying the ionosphere calibration data. Both pulsars were easily visible in both the calibrated and uncalibrated maps with signal-to-noise ratios > 20. To obtain the pulsar positions we

fitted a 2-dimensional gaussian to the pulsar image. The formal errors obtained from these fits are small (< 1 mas).

For PSR B1937+21, the position shift between the images made with and without ionosphere calibration is is small (less than a milliarcsecond). These observations were made during local nighttime and the ionosphere appears to have had a neglible effect on the apparent position of the pulsar. For PSR B0329+54, which was observed closer to local noon, the effects of the ionosphere are more significant; the position shift between the images with and without ionosphere calibration is approximately 4 mas in right ascension and 3 mas in declination. The best-fit positions (J2000, USNO reference frame) for these two pulsars, using the ionosphere-calibrated maps, are

PSR B0329 + 54	$\alpha = 03^h\ 32^m\ 59\overset{s}{.}3779$	$\delta = 54°\ 34'\ 43\overset{''}{.}493$,
PSR B1937 + 21	$\alpha = 19^h\ 39^m\ 38\overset{s}{.}5612$	$\delta = 21°\ 34'\ 59\overset{''}{.}135$.

Preliminary estimates of the systematic uncertainties due to errors in the ionosphere and troposphere calibration suggest that the uncertainty in these positions determinations is approximately 2 mas in each coordinate.

3. Frame-tie

It is well-known that comparison of interferometric and timing positions of millisecond pulsars can provide information about the offset between the VLBI-based extragalactic reference frame and the planetary ephemeris reference frame. The position we obtain for PSR B1937+21 is good agreement with previous interferometric studies of this pulsar (*e. g.* Dewey *et al.* 1996, Petit 1994; see also Bartel in these proceedings), and with independent frame-tie determinations (*e. g.* Folkner *et al.* 1994), and provides one of the best measurements of the frame-tie offset to date. Further VLBA observations of millisecond pulsars are currently scheduled and should improve the frame-tie.

Acknowledgments. We would like thank the Jet Propulsion Laboratory, particularly Brian Wilson, for providing the ionosphere TEC data.

References

Dewey, R. J, Ojeda, M.J., Gwinn, C. R., Jones, D. L., and Davis, M. M. 1996 AJ, 111, 315.

Folkner, W. M, Charlot, P., Finger, M. H ., Williams, J. G., Newhall, X. X., and Standish, E. M. 1994, A&A, 297, 279.

Petit, G. 1994, Ph. D. thesis, Paris Observatory.

Wilson, B.D., Mannucci A. J. & Edwards, C. D. 1995, *Radio Science*, 30, 639.