

Part 2

Precision Measurements

Section B

Astrometry

VLBI Position Determinations for the Millisecond Pulsar B1937+21

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Abstract. We determined with VLBI the coordinates of PSR B1937+21 and compare them with other determinations obtained with interferometry and timing. All the position estimates agree within one combined standard error, after the timing positions have each been rotated to the IERS extragalactic reference frame.

Millisecond pulsars can be used to tie earth-orbit-oriented reference frames to the IERS [1] extragalactic reference frame through a combination of timing and VLBI measurements. On 27 February 1987 we observed at 18 cm in left circular polarization the millisecond pulsar B1937+21 and, as a phase reference, the extragalactic radio source 1923+210 (OV239.7), about 4° away on the sky. We used NRAO's (25×27m) VLA near Socorro, the 43m antenna in Green Bank and OVRO's 40m antenna near Big Pine, and correlated the data with Haystack's MKIII A processor in the "gated" mode. Using phase connection and weighted least-squares estimation, we obtained for our observing epoch the following coordinates for PSR B1937+21 in the IERS frame:

$$\alpha(J2000) = 19^{\text{h}}39^{\text{m}}38^{\text{s}}.5613 \pm 0^{\text{s}}.0004$$

$$\delta(J2000) = 21^{\circ}34'59''.130 \pm 0''.003.$$

The errors are standard errors computed as the root-sum-squares of the statistical and systematic contributions.

In Figure 1a we compare VLBI and timing position determinations of PSR B1937+21 [2 (timing data kindly provided by J.H. Taylor), 3], after applying a proper-motion correction [3] to refer all positions to epoch 1990.0. We find agreement in both coordinates between all pairs of VLBI (B: [2], D: [4], P: [5]) and VLA (VLA-83: [6], VLA-90: [7]) measurements within the respective combined standard errors. However, the differences between the interferometric positions and those obtained directly from timing analysis can be rather large. These differences are not surprising, since each timing position is obtained in a separate reference frame effectively defined by the planetary ephemeris used. Pulsar coordinates determined in the frame of one specific planetary ephemeris can be converted to the frame of any of several other planetary ephemerides or to the IERS frame (via the rotation matrix of Folkner et al. [8]) with the conversion procedure given by us elsewhere [2].

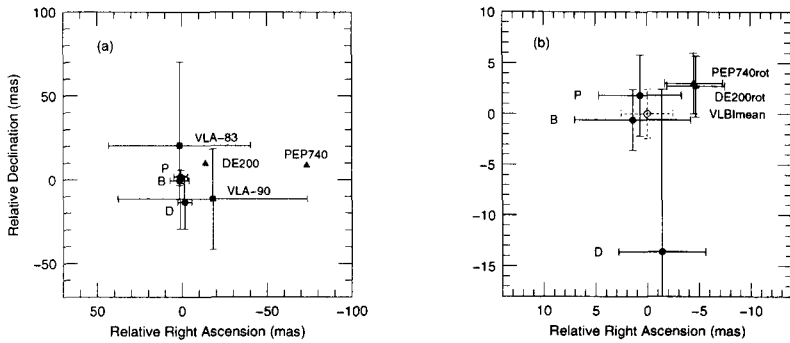


Figure 1. Determinations of the position of PSR B1937+21 obtained with VLBI, the VLA, and timing.

In Figure 1b we replot the VLBI results with an expanded scale and also show the weighted mean of the VLBI positions (dashed lines) and the DE200 and PEP740 timing positions rotated to the IERS frame. These results demonstrate the consistency of the various measurements and also provide a check on the frame tie derived by Folkner et al. [8].

References

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