MARK III VLBI OBSERVATION OF PULSARS [+]

N. Bartel[1], R.J. Cappallo[2], M.I. Ratner[1],
A.E.E. Rogers[2], I.I. Shapiro[1], A.R. Whitney

[1]Harvard-Smithsonian Center for Astrophysics
[2]NEROC Haystock Observatory

1. INTRODUCTION

Mark III VLBI observations of the pulsars PSR 0329+54 and PSR 1133+16 were made at 2.3 GHz using antennas with diameters and locations as follows: 100m, Effelsberg, West Germany (but only for SPR 0329+54); 43m Green Bank, WV, USA; and 40m, Big Pine, CA, USA. The Mark III processor at the Haystack Observatory was "gated" to compute visibility amplitudes and phases as a function of pulsar longitude. This method allowed a) an improvement of the signal to noise ration, by as much as a factor of ten in the case of PSR 1133+16, and b) an interferometric investigation of the pulse structure.

2. PULSAR ASTROMETRY

Observations of the pulsars and of compact extragalactic sources 0355+508 (NRAO 150) and 1119+183, each nearby in the sky to one of the pulsars, yielded the following positions (epoch 1981.21) and uncertainties given as the sum of our estimates of sistematic errors:

PSR 0329+54: $\Delta\alpha$(VLBI-PTA) = 0^{s}03 $\pm$

PSR 1133+16: α(1950) = 11^{h}33^{m}27.^{s}409 $\pm$0^{s}03, δ(1950) = 16°07'38".9 $\pm$0". 3.

These positions differ from those determined from pulse-time-of arrival measurements (PTA) by Manchester and Taylor (A.J.86, 1953, 1981) as follows:

PSR 0329+54: α(1950) = 03^{h}29^{m}11^{s}0133$\pm$0^{s}0005, δ(1950) = 54°27'37". 300$\pm$0". 005

PSR 1133+16: $\Delta\alpha$(VLBI-PTA) = 0^{s}056$\pm$0^{s}008, $\Delta\delta$(VLBI-PTA) = -0". 9$\pm$0". 3.

The errors shown are the root-sum-squares of the errors given above and the statistical standard errors given by Manchester and Taylor. The differences between the VLBI and PTA values, if significant, may be due mostly to the difference in orientation of the VLBI reference frame from that in which the timing positions are expressed.

3. UPPER LIMIT OF APPARENT PULSAR SIZE

In order to account for the total flux density variations of PSR+54, the correlated flux densities of all three interferometers were divided by the corresponding correlated flux densities for the interferometer with the shortest baseline. The width of a circular Gaussian determined by a least-squares fit to these normalized amplitudes is $0.23^{+0.13}_{-0.23}$ mas, where

275

the error was estimated by varying the gain of each station independently
by 15%.

UPPER LIMIT OF OFF-PULSE CONTINUUM EMISSION
The data for PSR 0329+54 were recorrelated using a gating window corres-
ponding to 0.8 of the pulsar period, centered between the pulses. All
of these "off-pulse" data were coherently integrated (~2.9 hours total)
by using the technique of phase referencing. No continuum emission was
detected at the position of the pulsar above a correlated flux density
level of 2.5 mJy (3σ). A separate limit was determined for the approx-
imately two minute period during which the received pulses were strongest.
This limit is less than 0.1 percent (4σ) of the flux density of the peak
of the average pulse during that period.

5. INTERFEROMETER PHASE WITHIN THE PULSE STRUCTURE
In order to search for position offsets between the emission regions of
the three components in the average pulse profile of PSR 0329+54, the
Green Bank-Effelsberg interferometer phase-delays for these components
were compared with each other (Figure 1). Upper limits (3σ) on any
differences between the positions of the three components are :
$\Delta\alpha < 20$ μas, $\Delta\delta < 50$ μas. An offset of 20 μas corresponds to an offset
of $\stackrel{\sim}{\sim} 7\times10^6$ km (less than five solar diameters)at an assumed distance of
2.3 kpc for PSR 0329+54. Also no significant phase differences were de-
tected within individual pulses, which were partitioned into 75 bins each
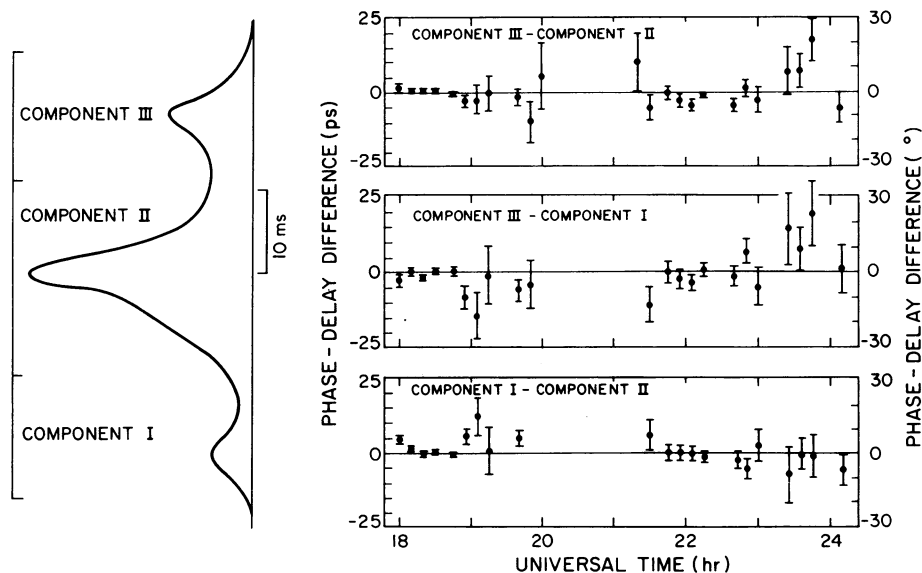of 715 μs extent.

Figure 1: Differences of interferometer phases for each pair of compo-
nents in the average pulse profile of PSR 0329+54 from observations with
the Green Bank and Effelsberg antennas. Error bars shown signify stan-
dard deviations (statistical).