THE STUDY OF SCATTERING EFFECTS BY VLBI OBSERVATIONS OF PSR 0329+54 WITH HALCA AT 1650 MHZ

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Abstract. PSR0329+54 was observed at 1.6 GHz with a space-ground radio interferometer with HALCA as a space radio telescope. The initial results of data processing are discussed.

Keywords: Interstellar scattering, VLBI observations

The VLBI technique is capable of measuring the angular distribution of scattered pulsar radiation, and at the same time studying its properties in the frequency and time domains. Bartel *et al.* (1985) investigated radiation from pulsar PSR0329+54 using MkIII VLBI observations at 2.3 GHz; they obtained an upper limit of 1 mas for the diameter of the scattering disk. Gwinn, Bartel and Cordes (1993) studied scattering of pulsar radio emission and the distribution of interstellar plasma fluctuations with the VLBI technique. Britton *et al.* (1998) tried to measure angular broadening of nearby bright pulsars, but they did not resolve their scattering disks.

The space VLBI program VSOP provides new possibilities for studying scattering phenomena in pulsar radio emission. There were several projects related to this subject, and the first preliminary results have been reported (Gwinn *et al.*, 2000; Minter, 2000).

In order to study ISS phenomena in relation to the Galactic interstellar medium, four bright pulsars covering a wide range of dispersion measures (DM) were chosen for the V006 space-ground VLBI experiment with the HALCA orbiting space antenna. In this publication we present preliminary results on PSR 0329+54.

The pulsar PSR0329+54 was observed at 1650 MHz (central frequency) on the 22 Aug, 1998, by a large network of ground radio telescopes including the VLBA (7 antennas), Green Bank, Goldstone, Robledo and the orbiting radio telescope HALCA. Data were acquired over 12 hours (~two HALCA orbits) within 32 MHz bandwidth with VLBA and Mk IV recorders (RO and GO). The telemetry from the space telescope was successively received by the Robledo, Tidbinbilla, Goldstone and Usuda tracking stations. The tapes were correlated at Socorro using also the gating mode of the correlator. Two hours of data (at the end of the session) were correlated with 512 channels per IF, but most of the observation was processed with 32 chan. per IF (spectral resolution 500 kHz). Three files in total were produced

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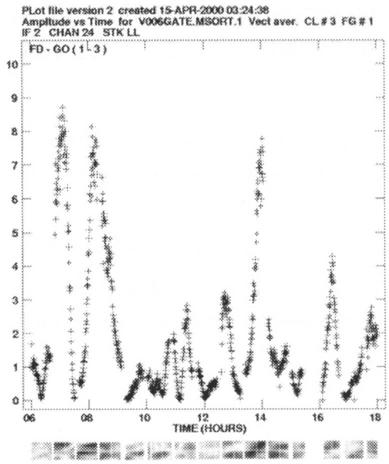

Figure 1. Visibility amplitude vs time for the Fort Davis – Green Bank baseline. Data for Ch 24 of IF2 is shown above the corresponding dynamic spectrum. The lower frequency channels lie at the bottom, higher frequencies correspond to higher levels in the dynamic spectrum bar; the bar width is ~32 MHz. The darker areas correspond to higher visibility amplitude. The same dynamic spectrum is shown on Figure 2.

by the correlator: gated, non-gated (with lower SNR) and a 2-hour high spectral resolution file. Then, the NRAO AIPS software package was used for post correlator data processing. The data were cleaned of RFI and spurious correlator signals (connected to pcals and scan edges), and the amplitude was calibrated taking into account individual bandpass responses. Individual fringe fitting was done for each of two IFs.

Figure 1 shows very strong amplitude variability of the pulsar visibility, – with modulation index, m, exceeding one within the VLBI session time interval. The strong peaks of Figure 1 correspond to speckle-like 'scintles' in the dynamic spectrum shown on Figure 2. Two images for the most prominent scintles located in the time range from 7h40m to 9h00m were built. They are shown in Figure 3

The left-hand image is based on data in 7:40–8:20 time and 1644–1649 MHz frequency ranges, the right one: 7:40–9:00 and 1654–1665 MHz. These areas correspond to maximum intensity in the dynamic spectrum (close to time mark 8:00 in Figure 2). In fact, one set of data coincides with that used by Minter (2000); a multiple imaging event was suggested by him as an explanation for the weak northern component (~16% of the peak level) seen in his Figure 3. Our two images of the source, obtained with both phase and amplitude self-calibration, were found to be quite similar and correspond to those expected for point-like structure of the source (see Cornwell, Anantharamiah and Narayan, 1989). There is no non-point-like structure in our images at the 1% level, though weak satellites at both sides of the main component have been seen at earlier steps of the phase and amplitude self-

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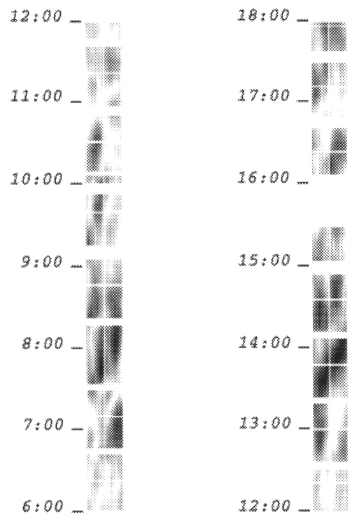

Figure 2. The dynamic spectrum of PSR0329+54 for the total observing interval 6:00–18:00. Time increases up. Left: the first half of the session, right: the second half. The left side of the strips corresponds to IF1 and the right one to IF2 and frequency increases from left to right. Gaps in strips are due to calibration scans.

calibration procedure (3 phase and 2 amplitude steps in total). In future, we will try to measure the relative positions of the images, obtained for different scintillation maxima in the dynamic spectrum.

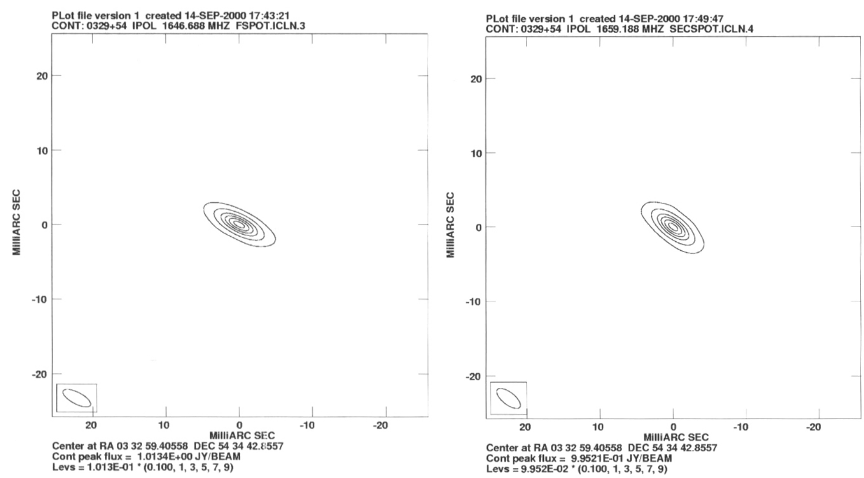

Figure 3. PSR0329+54 images built for two time-frequency areas of the dynamic spectrum. The left map has been restored from 1644–1649 MHz data (7:40–8:20 UT), while the right one – from 1654 – 1665 MHz data (7:40–9:00 UT). The contour levels are 1, 10, 30, 50, 70 and 90% of the peak flux.

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References

Bartel, N., Ratner, M.I., Shapiro, I.I., Capallo, R.J., Rodgers, A.E.E. and Whitney, A.R.: 1985, *Astron. J.* **90**, 2532.

Britton, M.C., Gwinn, C.R. and Ojeda, M.T.: 1998, *Astrophys. J.* **501**, L101.

Cornwell, T.J., Anantharamaiah, K.R. and Narayan, R.: 1989, *J. Optical Soc. America* **A6**, 977.

Gwinn, C.R., Bartel, N. and Cordes, J.M.: 1993, *Astrophys. J.* **410**, 673.

Gwinn, C.R., Reynolds, J.E., Jauncey, D.L., *et al.*: 2000, in: H. Hirabayashi, P.G. Edwards and D.W. Murphy (eds.), *Astrophysical Phenomena Revealed by Space VLBI*, pp. 117.

Minter, A.: 2000, in: H. Hirabayashi, P.G. Edwards and D.W. Murphy (eds.), *Astrophysical Phenomena Revealed by Space VLBI*, pp. 113.