

VERY LONG BASELINE INTERFEROMETRY OBSERVATIONS USING THE TRACKING AND DATA RELAY SATELLITE AS AN ORBITING RADIO TELESCOPE

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ABSTRACT. An antenna in geostationary orbit was used for VLBI observations at 2.3 GHz, in combination with ground antennas in Australia and Japan. 23 of the 25 observed sources were detected on orbiter-ground baselines, with baseline lengths as large as 2.15 earth diameters. Brightness temperatures between 10^{12} K and 4×10^{12} K were measured for 10 sources.

1. OBSERVATIONS

VLBI observations using a 4.9 m diameter antenna of the Tracking Data and Relay Satellite System were first performed in July and August 1986 (Levy *et al.*, 1986). In January 1987, additional observations were made, again using 64 m diameter ground antennas in Tidbinbilla, Australia and Usuda, Japan. The observing frequency was 2.3 GHz. 25 sources were observed, with a total observing time of 20 hours. The sources ranged in declination from 0° to -30° , and were observed at spacecraft hour angles of $180^\circ \pm 22^\circ$ (i.e. nearly towards the earth).

2. DATA REDUCTION

The data were correlated at Haystack, using the Mk IIIA correlator. Due to software limitations, it has not yet been possible to obtain closure phase values. The coherence fell significantly at short integration times, and then dropped more slowly. Measured values were 0.94 at 30 s., 0.86 at 100 s., 0.78 at 200 s., and 0.68 at 600 s. These are mean values; the standard deviations were 3% at 30 s., 9% at 100 s., 12% at 200 s., and 19% at 600 s. The reason for such a time-variable coherence is not known, but instabilities in the spacecraft electronics are suspected.

3. RESULTS

Of the 25 sources which were observed, 23 were detected, with data from one other lost due to equipment problems. The maximum baseline for each source depended primarily on declination, and ranged from 0.94 to 2.15 earth diameters. Visibilities on the maximum baseline for each source ranged from 0.11 to 0.68. The most compact source was 1519–273, with a visibility of 0.68 (1.1 Jy correlated flux) on a baseline of 2.02 earth diameters. With a fitted size of 0.33 milliarcseconds, the brightness temperature is 3.4×10^{12} K ($1+z$) (the redshift for this source is not known). Other sources with very high brightness temperatures were: 0336–019 (2.4×10^{12} K), 0420–014 (3.3×10^{12} K), 1921–293 (3.8×10^{12} K), and 2216–038 (3.4×10^{12} K). The errors on these values range from 10% to 35%.

4. DISCUSSION

Baseline lengths greater than 1 earth diameter are necessary to measure the structure of numerous compact radio sources. Two (1519–273 and 1921–293) of the three sources observed on baselines greater than 2 earth diameters displayed correlated flux greater than 1 Jy on those baselines. However, none of the sources were completely unresolved. Baselines of 1–3 earth diameters, available only with orbiting VLBI, promise to reveal a great deal about the structure of compact radio sources.

The measured brightness temperatures for 10 sources exceed 10^{12} K. If incoherent synchrotron radiation is the emission mechanism in these sources, the Inverse Compton process will limit the brightness temperature to $< 10^{12}$ K in the source rest frame. Bulk relativistic motion in the direction towards us, with a Doppler factor of at least 1.5–2, is required to explain the observations. This provides additional evidence that many (if not most) compact radio sources are significantly Doppler boosted in flux.

5. REFERENCES

Levy, G. S. *et al.* 1986, *Science*, **234**, 187.