WSRT Observations of hourly flux variations in OJ287 at 6cm wavelength

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Observations of short term flux variations provide one of the few means of determining the smallest scale sizes in compact radio sources. The fastest variations are generally found in BL Lac-type objects, OJ287 being one of the best studied. In 1985 Valtaoja et al. (Nature 314, 148) found evidence for variations at a level of (typically) a few % with a period of $15^m.7$ in OJ287 at frequencies of 22 and 37 GHz. [Such periodic variability was, however, not detected at 5 GHz during one of their observations by Dreher et al. (Nature 320, 239, 1986)].

In order to confirm and possibly improve on the reported results we have made two series of observations of OJ287, in the fall of 1985 and the fall of 1986, using the WSRT at 4.874 GHz. The September 1985 observations revealed a very dramatic drop in brightness and the 1986 observations were set up with sufficient calibration to ascertain the limiting factors of the WSRT for flux monitoring work. Contacts with D. Roberts (Brandeis) and J. Dreher (MIT) led to simultaneous coverage at the VLA for as much overlap as was possible.

In 1985 OJ287 was observed for three periods of 12^h on September 30 and November 10 and 16. The 1986 observations of OJ287 formed part of an $8x12^h$ project involving the sources 3C84, OJ287, CTD93 and BL Lac. Each source was observed twice with the expectation that, all things being equal, a division of successive 12^h lightcurves would eliminate all systematic, stable, system imperfections. The observations on 3C84, a supposedly nonvariable source, shows that this is indeed the case to an rms accuracy of 0.2-0.3% on scales of 1^m-12^h.

A total band of 80 MHz wide, in 8x10 MHz sub-bands, centered at 4874 MHz was recorded with a time resolution of 20^{sec}. The final resolution used was 60^{sec}. All combinations between two dipoles oriented at 0° and 90° position angle, were correlated. System temperature and gain calibration was done by firing a noise source every 10^{sec}. The theoretical noise level, for 1^m integration, was about 2 mJy, or 0.04% of the source flux density. The actual accuracy achieved was about 5 times worse for reasons still not understood.

We wished to obtain a continuous record of data on OJ287, and split-array observing being not (yet) possible, we could not switch to a flux reference at rapid intervals. [Because suitable reference sources

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are also much weaker than OJ287 the S/N ratio would have decreased had we made use of one]. We therefore chose to rely on the excellent stability of the WSRT and the diagnostic possibilities offered by the array redundancy.

The fastest variations seen are a 7% dip in a timespan of just over one hour in September 1985. Somewhat less dramatic, but more typical, variations are seen in the 1986 October data with $\Delta S/S \sim 1\%$ within one hour. The variations are clearly broadband (>80 MHz) and the suggestion of changes in the polarization state point to an intrinsic variation in the source. But this still needs to be further analysed.

Assuming a distance of about 1000 Mpc (z=0.3(?) and H_0=75 km/s/Mpc) the inferred brightness temperature approaches $\sim 10^{20}$°K depending somewhat on whether the whole source varies or whether a local hotspot comes and goes.

If one wishes to explain these variations within the context of the relativistically beamed radio source models, for which OJ287 certainly is a prime candidate, there is the restriction that the Lorentz factor Υ of the bulk motion cannot be greater than about 10. Otherwise the extended structure (about 0.2% of the core) would be too bright relative to the unbeamed core flux. Possible ways to explain these results, even for a $\Upsilon \sim 10$, are discussed in more detail in a paper soon to be submitted.

Preliminary analysis of the data reveals no periodic variations at any timescale. There is some evidence for a $\sim 15^m$ periodicity for about $1\frac{1}{2}$ hour around HA-50°→-40° on October 16, with an amplitude of about 0.3%. It is present in both polarisations but too close to the general noise level to be accepted as real. If such quasi-periodic variations are real large amounts of time are needed to confirm them.

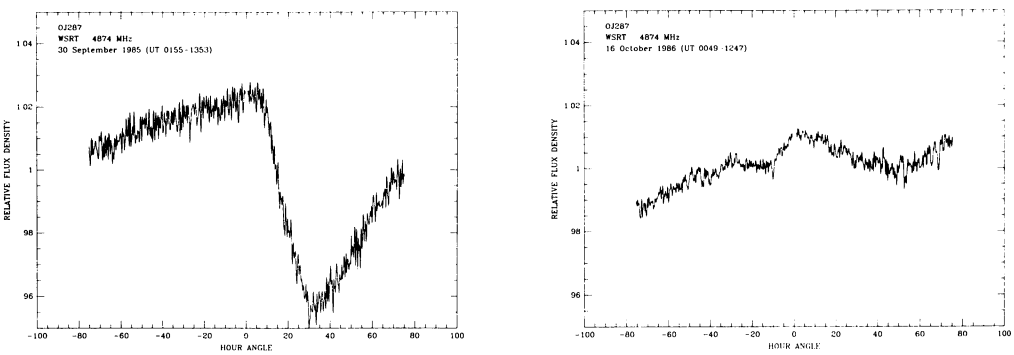

Figure 1. Two 10-hour lightcurves of OJ287 at 6 cm wavelength. The relative flux density (normalized to 4.6 Jy in 1986 and 4.0 Jy in 1985) is plotted versus the WSRT hour angle in degrees.

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