The 10-100 pc scale radio structure of the only radio-loud quasar at $z>6$

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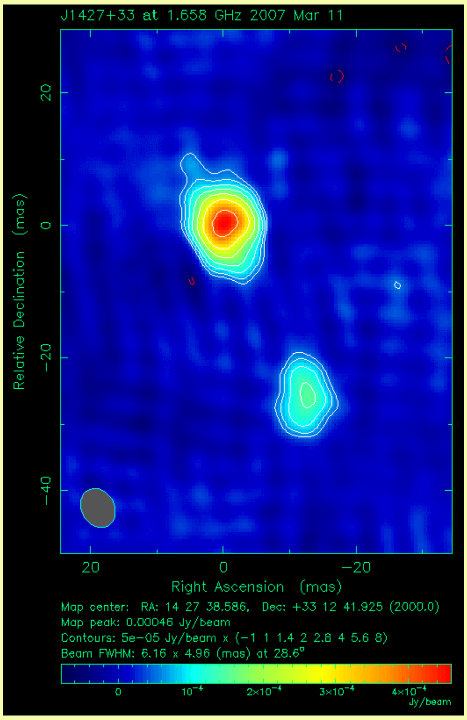
The quasar **J1427+3312** (z=6.12) was recently identified by *McGreer et al.* (2006) as the first radio-loud quasar at a redshift z>6. An independent identification was made by *Stern et al.* (2007). The source is found in the NOAO Deep Wide-Field Survey (NDWFS) region. Earlier radio measurements by the Very Large Array (VLA; the FIRST survey, *White et al.* 1997; the ELAIS, *Ciliegi et al.* 1999) and the Westerbork Synthesis Radio Telescope (WSRT; *de Vries et al.* 2002) give 1.4-GHz flux densities of 1.7-2.1 mJy. The source has been detected in several infrared bands. The optical and near-infrared colours, the broad absorption lines, and the possible intrinsic X-ray absorption implied by the Chandra non-detection (*Murray et al.* 2005) all suggest that dust extinction plays an important role in determining the appearance of this distant quasar. Assuming a cosmological model with H_0=70 km s^{-1} Mpc^{-1}, Ω_m=0.3 and Ω_Λ =0.7, the redshift z=6.12 corresponds to 0.9 Gyr after the Big Bang (<7% of the present age of the Universe).

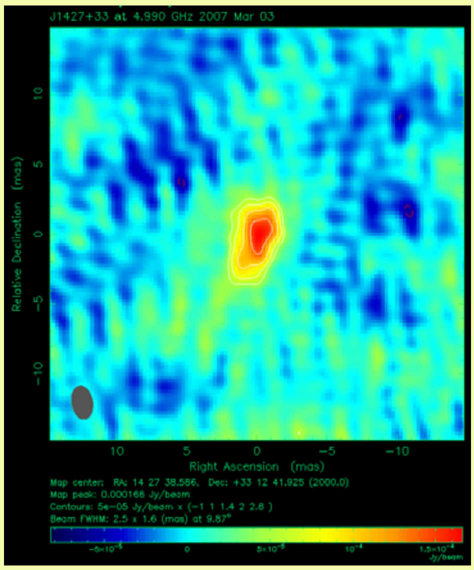


We observed J1427+3312 in phase-reference mode with the **European VLBI Network** (EVN) at 1.6 GHz on 11 March 2007, and at 5 GHz on 3 March 2007. The observed frequencies correspond to ~11 GHz and ~36 GHz in the rest frame of the quasar. At a recording rate of 1 Gbps, ten antennas of the EVN participated in the observations: *Effelsberg* (Germany), *Hartebeesthoek* (South Africa), *Jodrell Bank Mk2* (UK), *Medicina*, *Noto* (Italy), *Toruń* (Poland), *Onsala* (Sweden), *Sheshan*, *Nanshan* (P.R. China) and the phased array of the 14-element *WSRT* (The Netherlands). The data from the latter array were analysed as well, providing us with contemporaneous measurement of the total flux density of the source at these two frequencies.

The source was clearly detected with the EVN at 1.6 GHz, showing a prominent **double structure**. The two components are separated by 28.3 mas, corresponding to a projected linear distance of ~160 pc. Circular Gaussian model fitting indicates that both components are resolved (the brightest one with 0.92 mJy flux density and 5.7 mas FWHM, the weaker one with 0.62 mJy flux density and 18.6 mas FWHM). In the position of the brightest component at 1.6 GHz, we detected mas-scale radio emission at 5 GHz as well. The comparison of the VLBI and WSRT flux densities indicates that practically the entire radio emission of J1427+3312 originates from the components seen in the VLBI images. The radio spectral index of the feature detected at both frequencies is α=-0.6 (S~ν^α). The quasar with the second highest redshift known (z=5.77, SDSS J0836+0054) has also been studied with the EVN at 1.6 and 5 GHz (*Frey et al.* 2003, 2005), showing a single compact component. Its radio spectrum is similarly steep (α=-0.8).

The detailed discussion of our results can be found in *Frey et al.* (2008). J1427+3312 has also been observed and detected at 1.4 GHz with the NRAO Very Long Baseline Array (VLBA) in June 2007 (*Momjian et al.* 2008).

One may speculate that the two z~6 quasars known remind us to the well-known *Gigahertz Peak Spectrum* (GPS) sources (e.g. *O'Dea* 1998). Indeed, the known parts of their radio spectra are similarly steep. A convex radio spectrum of J1427+3312 that could possibly be obtained with multi-frequency flux density measurements at lower frequencies would prove this assumption. GPS sources are believed to be *young* (i.e. in the early stage of their evolution), or perhaps *frustrated* (i.e. confined by the dense interstellar medium). Given the early cosmological epoch at z=6.12, both scenarios seem plausible. In fact, early studies of the high-redshift (z>3.5) quasar population predicted that the space density of flat-spectrum Doppler-boosted sources rapidly declines at high redshift. These high-redshift objects may preferentially have steep spectra [*Savage & Peterson* (1983); see e.g. *Jarvis & Rawlings* (2000) for a more recent discussion]. It is interesting to note that the double structure and the separation of the components of J1427+3312 are similar to those of the young (<10^4 yr) ***Compact Symmetric Objects*** (CSO), a sub-class of GPS sources found typically in radio galaxies at much lower redshifts (e.g. *Wilkinson et al.* 1994; *Polatidis et al.* 2002).



At present, we know little about quasars at z~6, especially about the radio-loud ones, simply because our sample is very small. There are arguments (e.g. *Haiman et al.* 2004) in favour of a high surface density of z>6 radio-loud quasars, still to be identified spectroscopically.

J1427+3312 might prove to be a suitable background source to search for highly redshifted HI absorption in the line of sight.

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