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High-Resolution Radio Image of a Candidate Radio Galaxy at $z = 5.72$

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Saxena et al. (2018) reported the discovery of a possible radio galaxy at a redshift of $z = 5.72$, based on the detection of a single Lyα emission line. If it is indeed a radio galaxy, this would be the most distant known object of this type. The authors collected a sample of ultra-steep spectrum sources, with the spectral index $\alpha < -1.3$ ($S \sim \nu^{\alpha}$, where ν is the frequency and S is the flux density measured between 150 MHz and 1.4 GHz) and with compact radio morphologies using the TIFR GMRT Sky Survey Alternative Data Release (Intema et al. 2017), the Faint Images of the Radio Sky at Twenty-Centimeters (Becker et al. 1995) and the 1.4-GHz NRAO VLA Sky Survey (Condon et al. 1998). Only sources which were not detected in various optical (SDSS DR12, Alam et al. 2015; PAN-STARRS1, Chambers et al. 2016) and infrared surveys (AllWISE, Wright et al. 2010; UKIDSS, Lawrence et al. 2007) were further imaged with the Karl G. Jansky Very Large Array (VLA) at 1.4 GHz in its most extended A configuration. TGSS1530 (hereafter J1530+1049) was one of their brightest sources detected with a flux density of $S = 7.5 \pm 0.1$ mJy. It was unresolved in the VLA-A observation and its spectral index is -1.4 ± 0.1.

We observed J1530+1049 with the European Very Long Baseline Interferometry (VLBI) Network (EVN) at 1.7 GHz on 2018 Sep 19. The following radio telescopes provided data: a single antenna of the Westerbork Synthesis Radio Telescope (the Netherlands), Effelsberg (Germany), Medicina (Italy), Onsala (Sweden), Tianma (China), Toruń (Poland), Hartebeesthoek (South Africa), and Sardinia (Italy). Eight 16-MHz wide intermediate frequency channels were used in left and right circular polarizations. The observation was conducted in phase-reference mode (Beasley & Conway 1995). The target and the phase-reference calibrator (J1525+1107, its coordinates are known within an accuracy of 0.2 mas[1]) were observed alternately to facilitate the detection of the faint target and its precise relative astrometry. On-source time was 1.3 h. For the details of data reduction we refer to Gabányi et al. (2018). We detected two faint radio features in J1530+1049 with a separation of ~ 400 mas (Fig. 1), corresponding to ~ 2.5 kpc at $z = 5.72$ (assuming a flat ΛCDM cosmological model with $H_0 = 70\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$, $\Omega_\mathrm{m} = 0.27$). The position of the brighter northern feature is right ascension $15^\mathrm{h}30^\mathrm{m}49\overset{\mathrm{s}}{.}8903$ and declination $+10^\circ49'31\overset{''}{.}175$ with 1 mas estimated accuracy. The sum of the flux densities of the two components is 1.7 ± 0.2 mJy. Even taking into account its steep spectrum, the EVN observations recovered only a fraction of the flux density extrapolated from the VLA value. While this can be related to variability since the radio observations were not simultaneous, it is more probable that the missing flux density is in sub-arcsec structure compact on the VLA scale but resolved out by the EVN.

The radio power calculated from the VLA flux density ($\sim 10^{28}\,\mathrm{W\,Hz^{-1}}$, Saxena et al. 2018) and the projected source size derived from our EVN data place J1530+1049 among the medium-sized symmetric objects (MSOs). These are young counterparts of radio galaxies in the evolutionary diagram of An & Baan (2012). This is consistent with a radio galaxy in an early phase of its evolution as proposed by Saxena et al. (2018). Note that Momjian et al. (2018) recently imaged with VLBI a radio quasar at $z = 5.84$ that possibly shows MSO structure.

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[1] hpiers.obspm.fr/icrs-pc/newwww/icrf/, Charlot et al., in prep.

From our single-frequency radio image of J1530+1049, it is not possible to decide whether any of the components detected is a flat-spectrum radio core or both are steeper-spectrum hot spots where the jets interact with the dense interstellar medium of the host galaxy. Multi-frequency interferometric observations with ~ 0.1 arcsec resolution could answer this question.

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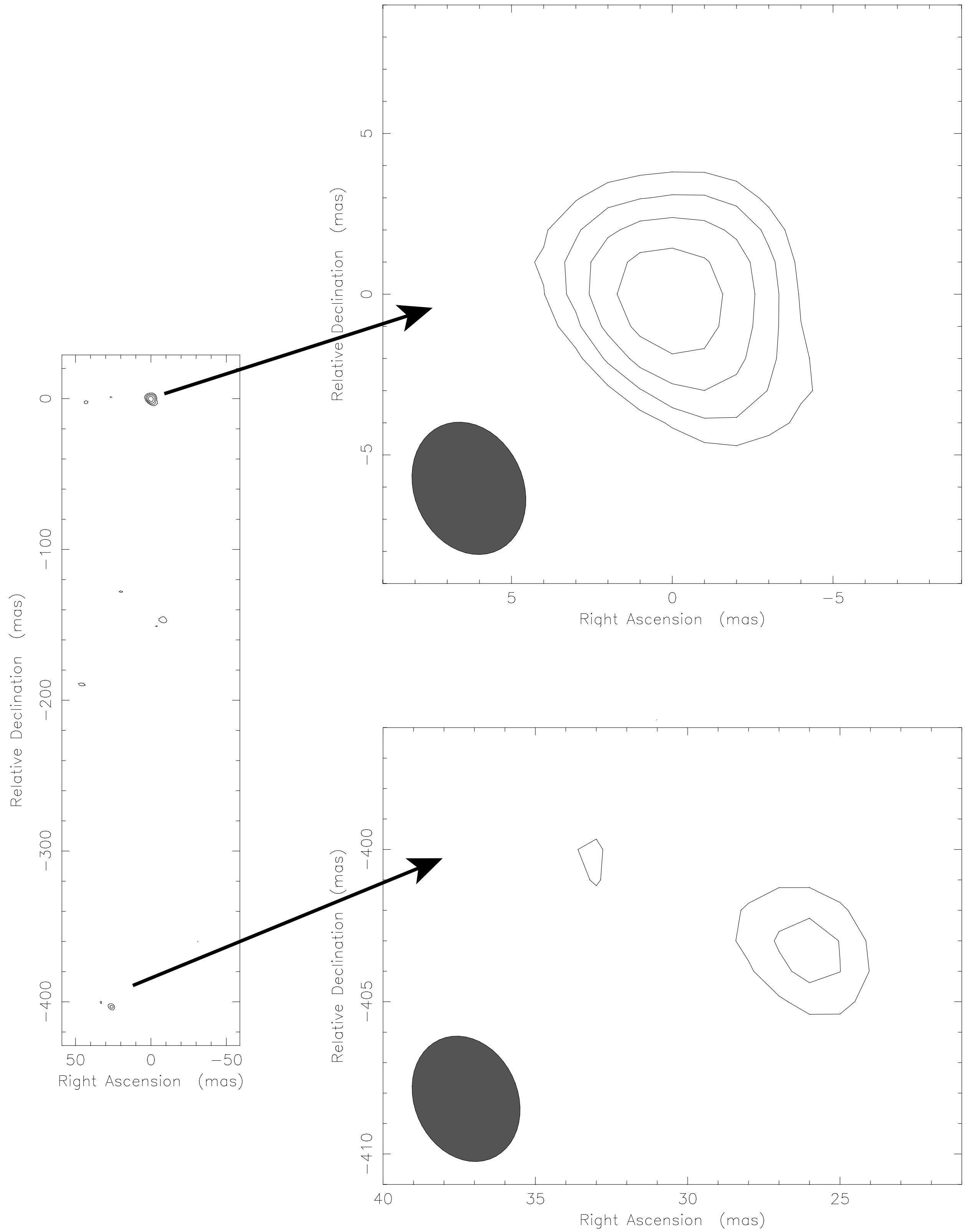

Figure 1. 1.7-GHz EVN radio image of J1530+1049. Peak intensity is 0.5 mJy beam^{-1}, the lowest contour is at 0.1 mJy beam^{-1} (3σ noise level), further contour levels increase by a factor of $\sqrt{2}$. The beam size is 4.3 mas $\times$3.4 mas at position angle 24°.

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