Zooming into the heart of a double-double radio galaxy with the EVN and e-MERLIN

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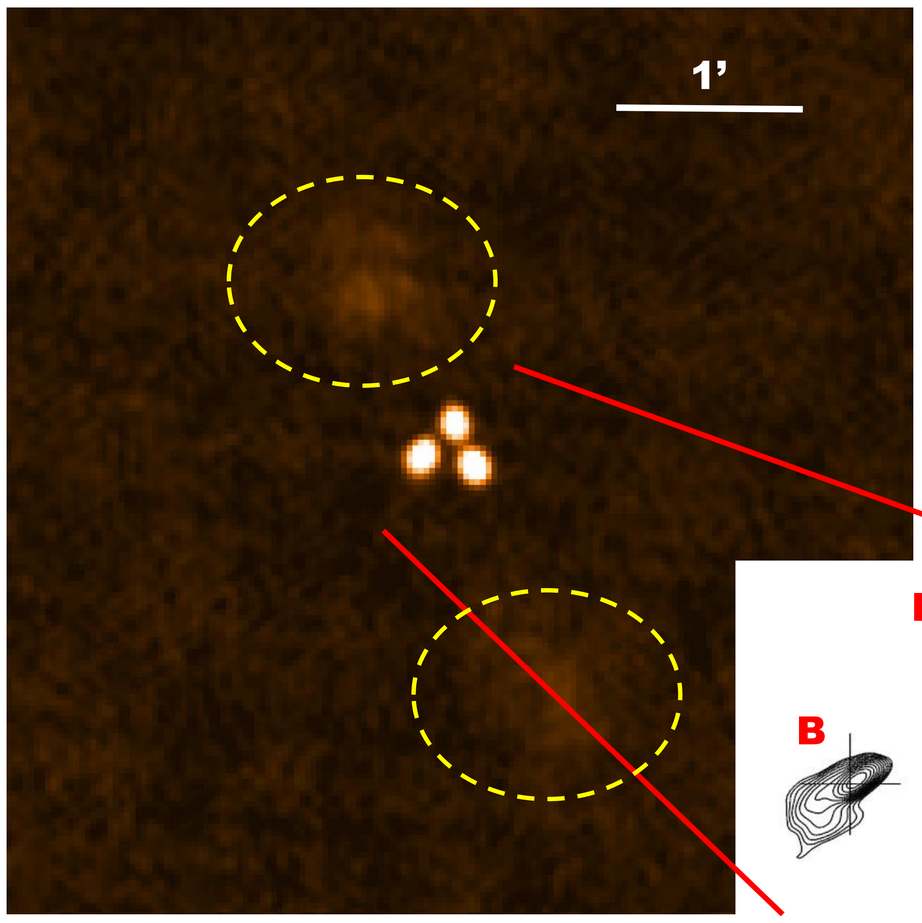
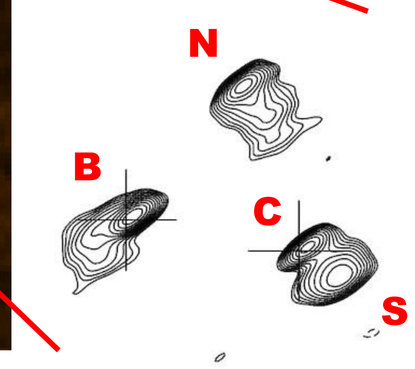


1.4-GHz Very Large Array (VLA) B-configuration image of J0028+0035 from the Faint Images of the Radio Sky at Twenty centimeters (FIRST) survey [1]. The eastern one of the inner three bright components is in fact an unrelated compact radio source (5BZU J0028+0035) seen close to the other two in projection [5]. The latter are the inner double lobes that are collinear with the faint and diffuse outer lobes



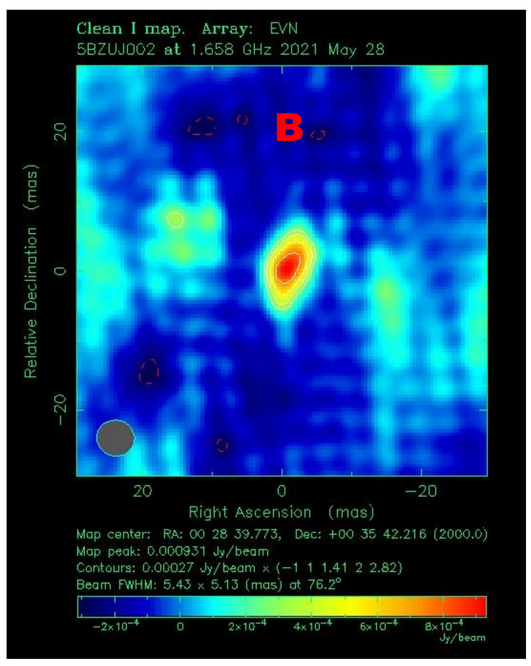
The inner part of the DDRG J0028+0035 in a 1.5-GHz VLA A-configuration image [5]. A central feature (**C**) between the two inner lobes (**N** and **S**), coincident with the optical position of the host galaxy marked by a cross, is revealed. The other cross on the left indicates the optical position of the unrelated blazar 5BZU J0028+0035 (**B**)

The radio source **J0028+0035** is a recently discovered **double-double radio galaxy** (DDRG; [5]) at redshift z=0.398. The relic outer lobes are separated by ~1.1 Mpc while the collinear inner lobes (**N** and **S**) span less than 100 kpc projected onto the sky.

In the arcsec-resolution radio images, there is also a **central radio feature** (**C**) that offers the intriguing possibility of being resolved into a pc-scale, third pair of innermost lobes. This would make J0028+0035 a rare triple-double source [2,4,6,8] where traces of even three distinct episodes of radio activity could be observed.

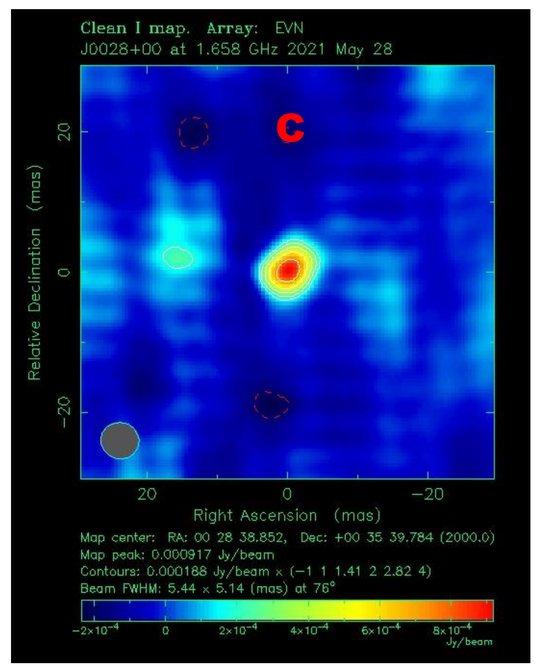
To reveal the compact radio structure of the central component, we conducted observations with the **European VLBI Network (EVN)** and the **enhanced Multi-Element Remotely Linked Interferometer Network (e-MERLIN)**. The 1.7-GHz imaging observations were made on 2021 May 28 (project EM152, PI: A. Marecki) using 18 telescopes. The phase-referenced observations (calibrator: J0029-0113) lasted for 4 h and were correlated at JIVE in a **multi-phase-centre mode**. The central feature (**C**) and the brighter (northern) inner lobe (**N**) of J0028+0035, as well as the blazar 5BZU J0028+0035 (**B**) were chosen as the 3 different phase centres, all falling within the primary beam of the antennas.

Not surprisingly, we did not detect the northern lobe **N** (brightness <0.27 mJy/beam, 6σ). The high-resolution 1.7-GHz image of the **J0028+0035 core shows a single feature**, i.e., no indication of a third, innermost double structure. A circular Gaussian model fitted to the visibility data indicates 1.3 mJy flux density and 3 mas angular size (FWHM). The inferred brightness temperature is ~10^8 K, typical for radio-emitting low-luminosity active galactic nuclei cores.



1.7-GHz EVN + e-MERLIN image of the coincident object in the background (z=0.686, [3]), 5BZU J0028+0035

1.7-GHz EVN + e-MERLIN image of the centre of the DDRG J0028+0035



As a bonus, thanks to the multi-phase-centre correlation, we could also image the nearby compact radio source 5BZU J0028+0035. Contrary to what is expected from a blazar listed in the Roma-BZCAT [7], this source is similarly **weak** (1.7 mJy) and **resolved** as the J0028+0035 core. For comparison, its FIRST integrated flux density is 20.8 mJy. Therefore, its identification as a blazar (i.e., a jetted AGN with a relativistically boosted radio emission) is questionable unless there is extreme flux density variability in the source.

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