Astronomers inspect a powerful radio-loud high-redshift quasar

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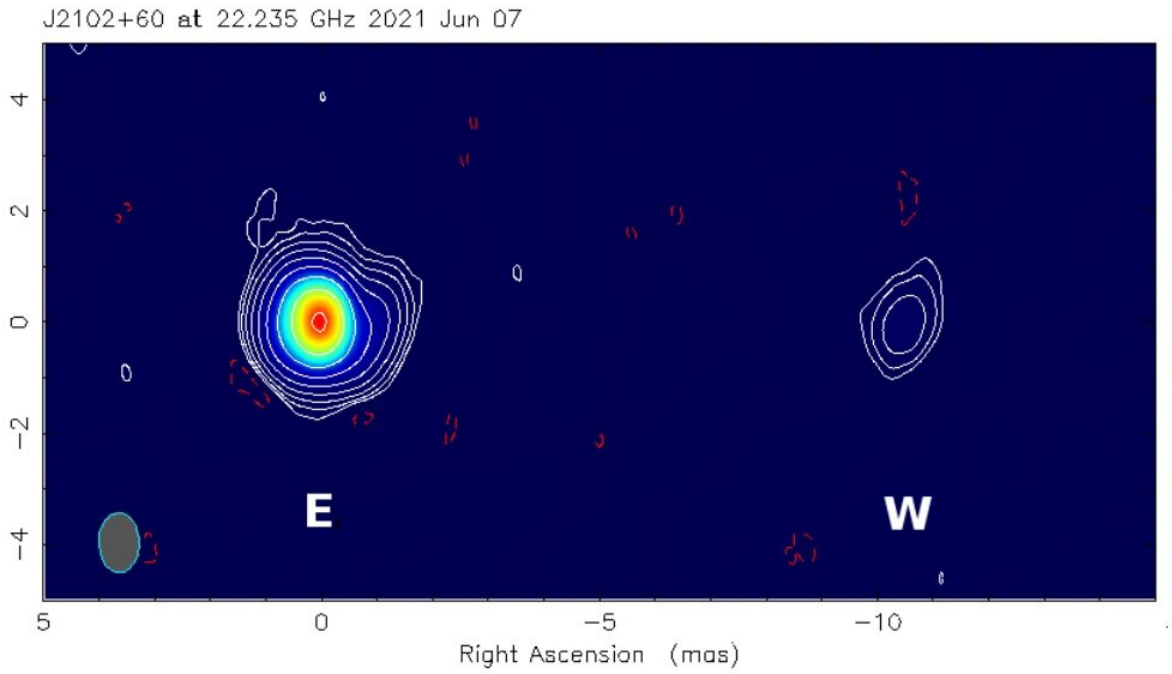

Naturally weighted 22-GHz EVN image of J2102+6015. The brighter eastern and the fainter western features are labeled as E and W, respectively. Credit: Frey et al, 2023

Using the European VLBI Network (EVN), an international team of astronomers has performed high-resolution imaging observations of a powerful and radio-loud high-redshift quasar known as J2102+6015.

Results of the observational campaign, presented January 18 on the preprint server *arXiv*, could help us better understand the nature of this peculiar quasar and other powerful radio sources.

Quasars, or quasi-stellar objects (QSOs), are extremely luminous active galactic nuclei (AGN) containing supermassive central black holes with accretion disks. Their redshifts are measured from the strong spectral lines that dominate their visible and ultraviolet spectra.

Astronomers are especially interested in finding new high-redshift quasars (at redshift higher than 4.5) as they are the most luminous and most distant compact objects in the observable universe. Spectra of such QSOs can be used to estimate the mass of supermassive black holes that constrain the evolution and formation models of quasars. Therefore, high-redshift quasars could serve as a powerful tool to probe the early universe.

J2102+6015 is a powerful radio quasar at a spectroscopic redshift of approximately 4.575 with a prominent complex radio structure. However, although several observations of J2102+6015 have been conducted to date, its true nature remains uncertain. Some studies have suggested that it may be a gigahertz peaked-spectrum (GPS) source, while others have proposed that it may be a young compact symmetric object (CSO), excluding a blazar scenario.

Therefore, in order to shed more light on the properties of J2102+6015, a group of astronomers led by Sándor Frey of the Konkoly Observatory in Budapest, Hungary, performed a very long baseline interferometry (VLBI) analysis of this source.

"The quasar J2102+6015 has never been studied with VLBI at frequency bands different from 2 and 8 GHz. Motivated by the apparently non-blazar nature and the puzzling mas-scale radio structure of this source,

we conducted 5- and 22-GHz imaging experiments with the European VLBI Network (EVN) in June 2021," the researchers wrote in the paper.

The new VLBI observations allowed the team to distinguish two main structural elements of J2102+6015—the brighter eastern (E) and the fainter western (W) features. These features are known from the earlier images of the source and their separation was calculated to be about 10 mas.

Furthermore, the new EVN images revealed a faint "central" component between the E and W features which may be a core of a CSO. In general, the results indicate a slowly growing jet in the CSO phase, which is consistent with the expectation from previous studies. According to the astronomers, this means that the radio power will continue to increase with time with the source expansion.

The researchers noted that J2102+6015 is therefore a young radio source with its jets misaligned with respect to the line of sight. It appears that the quasar experiences quasi-periodic variation, with a duration of about three years, in its absolute position.

More information: S. Frey et al, J2102+6015: an Intriguing Radio-loud Active Galactic Nucleus in the Early Universe, *arXiv* (2023). DOI: 10.48550/arxiv.2301.07355