High-resolution radio imaging of the gamma-ray blazar candidate J1331+2932

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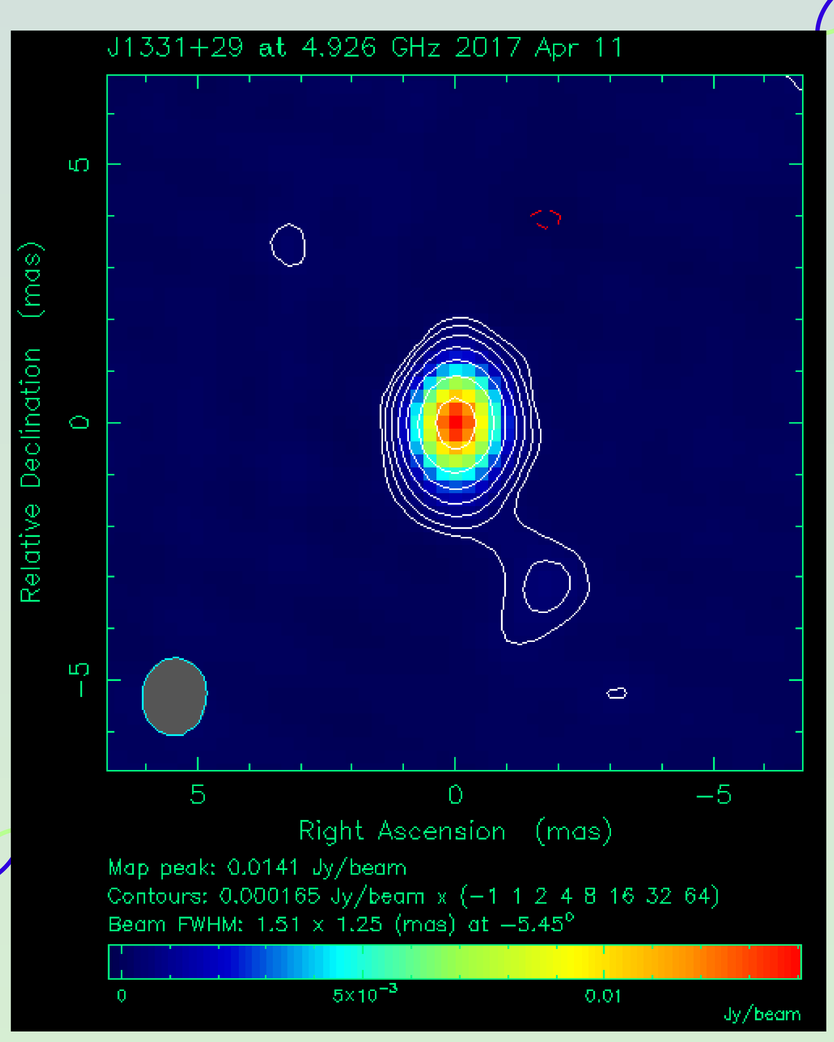
When looking for evidence for γ-ray flaring activity in the stellar binary system DG CVn, recently Loh et al. (2017) found a **transient source** using *Fermi* Large Area Telescope (LAT) data. However, since simultaneous flaring of DG CVn was not reported at any other waveband that time, the background quasar J1331+2932 fell under suspicion as the possible **source of the γ-rays**. Among the γ-ray emitting extragalactic sources, blazars constitute the most populous group (Ackermann et al. 2015). Milliarcsecond-resolution **radio interferometric** observations are the best suited for providing the ultimate evidence to discriminate between a blazar and non-blazar radio-emitting active galactic nucleus (AGN). We observed J1331+2932 with the European Very Long Baseline Interferometry Network (EVN) at 5 GHz.

Since the brightness of the source was not known, the method of phase referencing was used. This involved regular observations of the nearby (1.4°) compact calibrator J1334+3044 within the atmospheric coherence time. The total time spent on the source was about 140 min. Using the reference object, the **coordinates** of the blazar candidate could be determined **more accurately than before:** RA = $13^h\ 31^m\ 01.83259^s$, Dec = 29° 32’ 16.5099”. The estimated error in the position is 0.5 mas.

Nine telescopes of the EVN were used, including Tianma, China and Hartebeesthoek, South Africa, thus a high resolution was achieved with **intercontinental baselines**. As it can be seen on the map, the source consists of two components, a bright core and a weak jet. The core has a peak brightness of 14.08 mJy/beam and the noise is 0.06 mJy/beam. This signal-to-noise ratio and the half-power beam size correspond to a minimum resolvable size of 0.09 mas (Kovalev et al. 2005).

Tianma 65 m radio telescope near Shanghai, China



The data were calibrated and analysed with the AIPS (Greisen 2003) and Difmap (Shepherd 1997) software.

The circular Gaussian model fitted to the core after self-calibrating the data shrank to a point regardless of whether a second Gaussian component was fitted to the jet or not, which implies that **the core is compact**. The upper limit of the size of the core is the minimum resolvable size. The redshift of the source is 0.48 (Alam et al. 2015). This yields that the minimum **brightness temperature** of J1331+2932 is $T_{\mathrm{B}} \gtrsim 1.3\times10^{11}\mathrm{K}$ (Condon et al. 1982).

Supposing an intrinsic brightness temperature of $T_{\mathrm{B,i}} \approx 3\times10^{10}\mathrm{K}$ as suggested by Homan et al. (2006), the lower limit of the Doppler factor is $\delta \approx T_{\mathrm{B}}/T_{\mathrm{B,i}} \gtrsim 4$. Assuming that the Lorentz factor has a typical value of $5 \le \gamma \le 15$, the **viewing angle**, θ can be estimated using the $\delta = \frac{1}{\gamma(1-\beta\cos\theta)}$ formula, where β is the bulk speed of the jet in units of speed of light. This gives that $\theta \le 14°$.

Based on our EVN data, we confirm that J1331+2932 is a blazar and thus the most likely counterpart of the *Fermi* LAT source. *Wide-field Infrared Survey Explorer* (WISE, Wright et al. 2010) data show significant flux density variations in the infrared.

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