High-resolution radio imaging of the distant blazar J1429+5406

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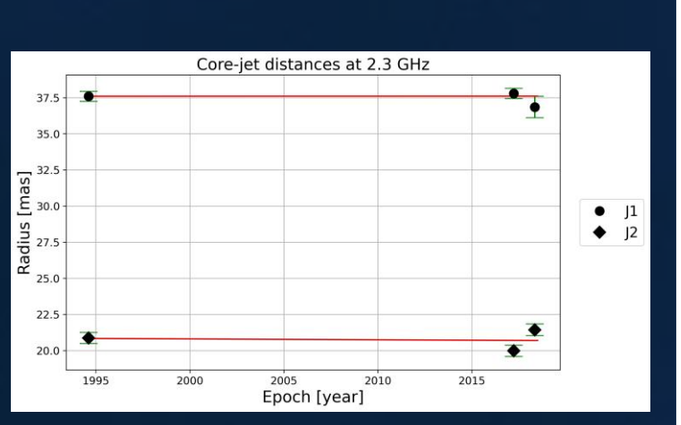
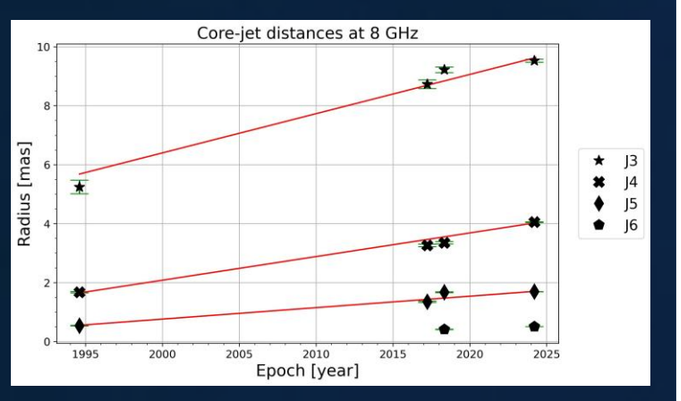
Introduction

Our understanding of jet kinematics in z~3 quasars is still rather limited, based on a sample of less than about 50 objects. We present VLBI observations of the powerful blazar J1429+5406 at z=3.015, observed at six frequencies (0.4, 1.7, 2.3, 5, 8.4, 15 GHz) between 1994 and 2024.

Proper motions of the inner jet components

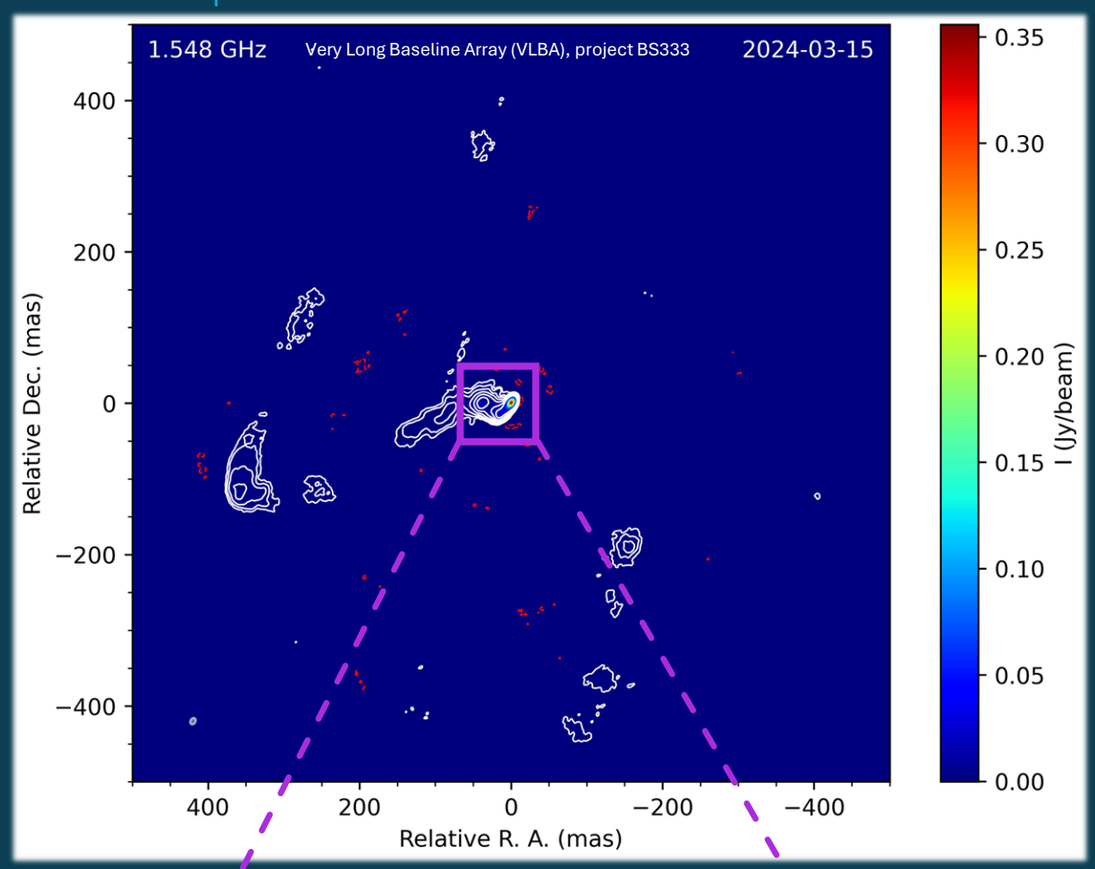




While outer jet components (J1, J2) at ~20 – 40 milliarcseconds (mas) from the core show no apparent motion, three components within 10 mas exhibit significant proper motions (0.039–0.13) mas yr^{-1}, including one that is among the fastest-moving jet components at z≥3 known to date [1, 2]. The apparent speeds of quasar jets at high redshifts are typically in the range (0.2-10)c, where c is the speed of light [1].

Core–jet structure at multiple frequencies

The upper map reveals a complex, extended radio structure around the core, reaching up to ~400 mas – rarely, if ever, seen in a high-redshift blazar. The lower map zooms into the compact, bright core along with multiple extended and fainter jet components at various separations from the core.



New observations: Thanks to the highly sensitive new VLBA measurements (project BS333, 2024), we were able to map the ~0.4 arcsec scale structure. This may indicate a precessing jet which we plan to model, to constrain its geometry.

Apparent linear proper motions and speeds of the inner jet components J1 - J5.

Comp.	μ [mas year^{-1}]	β [c]
J1	-0.0003 ± 0.02	–
J2	-0.01 ± 0.05	–
J3	0.13 ± 0.02	14.0 ± 2.5
J4	0.080 ± 0.004	8.27 ± 0.4
J5	0.039 ± 0.004	4.0 ± 0.4

Inner jet parameters

Using the apparent speed of the J5 component that is the closest to the jet base and the brightness temperature of the core measured at 5 and 8 GHz, we arrived at an estimate of the Doppler factor $\delta \approx 25$ and the bulk Lorentz factor $\Gamma \approx 12$. We could constrain the jet inclination angle to $i \approx 0.5°$. The latter value firmly places J1429+5406 among blazars which have jets oriented very close to the line of sight. The blazar nature of this source is further supported by its detection in γ-rays [3].

The new findings, based on three decades of observations, are consistent with our previous constraints on the physical parameters of the jet, derived from the first ~25 years of VLBI data [4].

The bulk Lorentz factor characterising the jet of J1429+5406 is consistent with typical values found in low-redshift blazars ($10 \lesssim \Gamma \lesssim 20$) [5, 6]. This suggests that there is no fundamental difference between jet physics at low and high redshifts.

Read more here: Koller, D., & Frey, S., (2025): Superluminal Motion and Jet Parameters in the High-Redshift Blazar J1429+5406. Universe, 11, 157.

References:

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