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2251 + 158 (3C 454.3): Detection of an arc-like structure on parsec scales

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Abstract

Context. 2251+158 (3C 454.3) is a well-studied quasar with rather unusual properties. It is among the most variable and brightest gamma-ray emitting active galactic nucleus (AGN) in the sky observed by Fermi. The multi-wavelength flux density emission of this source is peculiar, and so is the very long baseline interferometry (VLBI) structure. While it is usually assumed that the jet and jet-components in a given AGN show more or less the same properties (e.g., apparent velocities and paths) with time, we demonstrate here that unusual morphologies (arc-like structure) can occur as temporal phenomena. We also show that the kinematic properties of jet components change from slow to fast apparent motion. Aims. We present the detection of an arc around the core region. To understand the physical nature of this and other peculiar kinematic properties of the parsec-scale jet of 2251+158 we performed detailed radio-interferometric studies of this prototypical AGN. Methods. We (re-)analyzed 32 Very Long Baseline Array (VLBA) observations covering 16 years in time (between 1995.57 and 2011.48), observed at 15 GHz from the Monitoring Of Jets in Active galactic nuclei with VLBA Experiments (MOJAVE/2 cm) survey and derived the parameters of the observed VLBI structure. Three 43 GHz VLBA observations from 2001.22, 2005.38, and 2005.76 have been reprocessed. We fitted the components of the VLBI structure with Gaussian components. We studied the properties of light-curves obtained in the radio (4.8, 8.0, and 14.5 GHz) and optical regime (R-band), and studied the correlations between the flaring properties and the VLBI structure of the source. Results. We report the detection of an arc-like structure around the core of an AGN. This ring-structure becomes visible in VLBI maps around 1996. It expands with an apparent proper motion between 0.12 ± 0.01 mas yr-1 and 0.19 ± 0.01 mas yr-1 (corresponding to 5.4 ± 0.3c to 9.0 ± 0.4c) and dominates the parsec-scale structure for about 14 years. In addition, we report a significant change in the kinematic properties of jet components close to the core. A phase of slow apparent radial motion (directed away from the core) of two inner jet components (A and B) and no component ejection after a major radio-flare in 1995 is atypical for AGN. This phase is followed by a more typical behaviour in which the same components separate with higher apparent speeds from the core and two new components appear to be ejected from the central region. Conclusions. We observe significant changes in the morphological and kinematic properties of the parsec-scale jet. Taken together, it is tempting to see a causal connection between the different phenomena. We briefly suggest and discuss several possible physical scenarios to explain the observed phenomena. The kinematic changes as well as the changes in the flaring characteristics could be explained geometrically because of a change in the angle to the line of sight towards the observer assuming a helical structure of the jet. Another possible explanation for the observed phenomena and the correlations among them could be a precessing jet (precession period on timescale of 14.5 years) in combination with its interaction

with an external inhomogeneous medium surrounding the core. These and other possible explanations will be investigated further and manuscripts presenting the results are in preparation. © 2013 ESO.

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Keywords

Quasars: individual: 3C 454.3, Radio continuum: galaxies, Techniques: interferometric