HST observations of the AGNs with large VLBI/*Gaia* position offsets

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The *Gaia* DR1 catalogue of 1.14 billion objects released in 2016 provides absolute positions of 1.14 billion objects with milliarcsecond accuracy. Comparison of Gaia DR1 positions against 7669 matching active galaxy nuclea (AGNs) from VLBI absolute position catalogue showed that the distribution of position offset directions has a strong anisotropy with respect to the parsec-scale radio jet direction (Petrov & Kovalev 2017a, Kovalev et al. 2017). Position offsets less than 3 mas have a preferred direction both along and opposite to the jet direction. Position offsets greater than 3 mas occur predominately along the jet. We present extensive argumentation in (Petrov & Kovalev 2017b) that the most probable explanation of this phenomena is the presence of an optical jet at scales 1–200 mas that shifts the optical centroid. We presented evidence that observed VLBI/*Gaia* positions offsets occurs mainly not because the differences in optical and radio structure, but because the response of a quadratic detector, such as CCD, and a radio interferometer that records voltage to an extended object is fundamentally different: positions derived from analysis of a quadratic detector corresponds to the centroid, while positions derived from analysis of a radio interferometer data in most of the cases correspond to the position of the most compact detail, usually, the optically thick jet base. Therefore, the differences in the position is due to the presense of optical structure that shifts the optical centroids with respect to the jet base.

We found a number of radio sources with statistically significant offsets in a range of 10 to 200 mas with the probability of false associations of radio and optical sources less than $1 \cdot 10^{-4}$. The distribution of the position offsets with respect to the jet direction among these sources has a strong peak at the position angle 0°, which corresponds to the Gaia position offset with respect to the VLBI position along the jet. If our interpretation is correct, we expect these sources should have jets beyond 100–200 mas, i.e. HST resolution or any other peculiarity associated with jets.

VLBI detects jet for the majority AGNs, while optical jets are currently known at about two dozens of sources, mainly due to HST observations. The sources with large offsets along the jet

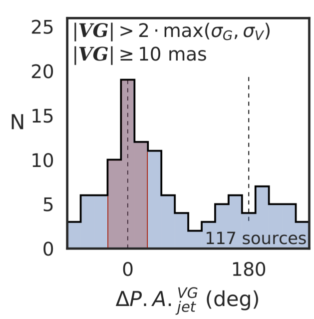

Figure 1: The distribution of *Gaia*/VLBI offset directions with respect to the radio parsec-scale jet direction. A sub-sample of offsets longer 10 mas and exceeding 2σ of both VLBI and *Gaia* position uncertainties used in used here (Figure 3 in Kovalev et al. (2017)). The sources in the shadowed area are proposed for HST observations.

are good candidates for having detectable optical jets.

The goal of the proposed observations is to shed light on the nature of the observed VLBI/Gaia position offset that favor the jet direction. The HST images will serve as a probe of the proposed explanation of the discovered significant shift between VLBI and Gaia positions is correct or to come out with an alternative explanation. We propose to observe 41 AGNs with the position offsets VLBI/Gaia in a range of 10–200 mas that have offsets within 30° of the jet direction (the main peak in Figure 1). Of them, 14 are galaxies according to PanSTARRS images. We will analyze the HST images and try to detect the jet. A negative result: a lack of a detectable optical jet will be useful for constraining models of VLBI/Gaia offsets.

These results will allow us to fine tune the new method to model-reconstruct optical images on milliarcsec scales for hundreds of AGNs on the basis of VLBI and Gaia data in the future. The proposed observations are a part of a large all-sky program for follow-up radio observations of the sources with significant VLBI/Gaia offsets.

References

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