# A study of bent jets in active galactic nuclei at parsec scales

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#### What Is Done In Brief

- 1. Analysed **73 000 images** of about **11 000 AGNs** at various frequencies
- 2. Filtered images with resolved extended jet structure
- 3. Revealed ridgelines of jets for each image
- 4. Identified **214 sources** with significantly bent jets (fiq. 1)
- 5. Modelled jets with simple geometries to constrain



possible bending hypotheses (fig. 2) 6. Obtained the distribution of best-fit-models (fig. 3)

> Figure 1. Quasar J1327+2210: an example of the source with different jet directions probed at different scales which represents a helix-shaped structure of the entire jet. The black arrows indicate the jet position angle. Restoring beam at the half-power level is shown in the bottom left corners.

## The Challenge

It is observed that some active galactic nuclei (AGN) jets exhibit bending even at parsec scales. Our task is to perform multi-frequency analysis of AGN VLBI images, find sources that exhibit some degree of bending (fig. 1) and suggest possible physical mechanisms in charge.

#### Data Used

In our research we use Astrogeo VLBI FITS image database. We performed analysis of 73 000 images of about 11 000 AGNs. The vast majority of images had no extended structure resolved.

## Images Filtering

We fitted all of the images with 2D gaussians. If one gaussian is not enough to fit the brightness distribution we assume that the image has no extended source structure.

### Extracting AGNs With Bent Jets

To extract AGNs with bent jets we stacked their ridgelines, fitted them with Archimedes (linear) helix and calculated the angle of helix rotation. Each source with helix rotation angle > 20 deg became candidate. The number of candidates was ~ 1000. Then we manually chose AGNs with bent jets (214 objects).





Figure 2. Examples of best fits done in polar coordinates with: a) linear helix; b) logarithmic helix; c) 2 helical segments. Lines with dots represent computed ridgemlines of the whole mapset of each source. Image b<sub>2</sub>) illustrates how models are fitted in polar coordinates.



#### Fitting with Simple Models and First Results

To understand overall trends in jets geometries we fit them with simple models: linear helix, combination of 2 helical segments, logarithmic helix, line with 2 segments. We perform fitting in polar coordinates (distance from the core VS positional angle, fig.  $2-b_3$ ). After the fitting we chose the best models by Bayesian Information Criterion (BIC). The distribution of AGN jets geometries was obtained (examples: fig. 3).

Figure 3. The distribution of best-fit-models (done in polar coordinates) of the AGNs with curved jets.

#### Possible Reasons for Bending

There are several conventional physical mechanisms that are likely to make jets bent at parsec scales: • Precession of the jet nozzle • Kelvin-Helmholtz instabilities • Collisions with the medium (Savolainen et al. 2006; Lister et al. 2002; Hong et al. 2003). We are currently working on association of these hypotheses with our streamlines modeling.