

Temporal and spatial variability of the active galactic nuclei used in celestial reference frames

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Very Long Baseline Interferometry (VLBI) is a radio astronomical observing method that allows reaching the best angular resolution among the available astronomical observing methods. In VLBI a set of radio telescopes, located across the globe, is combined into a single large virtual telescope. Even though observing in radio frequencies is intrinsically less accurate than in optical frequencies, the fact that radio telescopes can be connected interferometrically in global scale is more than enough to compensate the limitations of the comparably longer wavelengths. VLBI images of the radio sources are obtained by correlating the signals of each pair of telescopes, called baselines, and solving the image as an inversion problem.

VLBI observations have a practical use case in geodesy as the most accurate available method for determining the orientation and rotation of the Earth. Using only positioning satellites it is possible to determine the location of the ground with respect to the satellite constellation, however it can not directly provide the orientation of the observer – or of the Earth itself – relative to inertial space. VLBI allows determining this orientation with respect to some distant extragalactic radio sources. Using extremely distant active galactic nuclei (AGNs) as fixed reference points VLBI can be used to define and monitor the orientation, encoded in the Earth Orientation Parameters (EOP), with high precision.

VLBI Global Observing System (VGOS) is a new VLBI observing network dedicated for the use of geodesy and astrometry. The network has been in use since 2020 but it is still being expanded and developed. Legacy VLBI network consists of heterogeneous set radio telescopes with wide range of antenna sizes, slewing speeds and instrumentation, whereas VGOS consists of a more uniform set of telescopes optimised for geodetic use, where the priority is to observe sufficiently well as many reference sources as possible. One of the upcoming VGOS telescopes is located in the Metsähovi Geodetic Research Station.

The first aim of the MSc work is to calculate flux densities and flux density based signal-to-noise (SNR) estimates based on available VGOS observation data. The flux densities are calculated for each baseline and aggregated into values for each sources. These results have a direct application in increasing the efficiency of the observing sessions. The accuracy of the EOP results depend on the number of observed reference sources and to maximise the number of sources per session it is desirable to not observe the sources more than what is necessary to reach a sufficient SNR level. The observing times are scheduled before the session based on some estimations of the source flux densities and SNRs, and comparing these estimations with the observed flux densities and SNRs could allow improving the estimations in the future.

The second aim of the work is to investigate changes observed among the sources and connect these findings with the observation based flux densities calculated for the first aim. Even though AGNs that appear as point like and unvarying as possible are chosen, they can be resolved as extended sources using VLBI and they show variability. The changes in extendedness are calculated based on existing VLBI images of the sources obtained from public database, such as The Astrogeo VLBI FITS image database or The Bordeaux VLBI Image Database. Studying the variability of the AGNs is interesting in itself, but it also has a practical application as better knowledge of the variability allow making better estimation for scheduling geodetic VLBI sessions.

The current status of the work is that preliminary results from the flux density and shape calculations have been made, demonstrating that the data handling and calculation scripts seem to work. The next step is to validate the preliminary results by comparing them with the literature and other available data.