Detection of the background position noise due to non-stationary of the Galactic gravitational field. Pilot project.

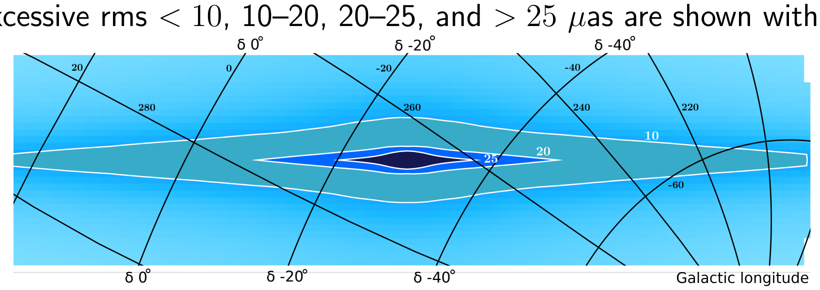
1 Introduction

Motion of stars in our Galaxy makes the gravitational field non-stationary. Radio waves propagating in the non-stationary gravitational field deflect and their deflection can be described as a stochastic process. Theoretical simulations based on the modern models of stellar mass function described in Larchenkova et al. (2017) predict the rms of the arc lengths of a pair of AGNs to exceed 20 microseconds over 5 years if a pair is located within 1.5 degree of the galactic plane at the distance closer 20 degrees of the Galactic center (See Figure 1). Such a jitter sets a fundamental limit in astrometric accuracy. Detection of such a limit is the long-term goal of our project. We propose to observe two groups of 20 pair of sources: one group within $l < 20°$ and $|b| > 1.5°$ and another group with $|b| > 30°$. The goal of a large program is to detect a systematic increase of rms in arc lengths in a group of sources within the Galactic plane with respect to the group of sources with high galactic latitude. The positive outcome of this program, a detection of such an increase in the rms will confirm the existence of the fundamental limit in positional accuracy that will not be broken for centuries. In order to overcome such a barrier, a telescope should be placed at a distance of several kiloparsec above the Galactic plane. It is very unlikely we will have such capabilities any time soon. Before space flight at kiloparsec distances will become feasible, the positive outcome obtained in this project result will be held. A positive outcome of the program will demonstrate the applicability of the stellar mass function and the models of stellar mass distribution. The negative result will mean that the used stellar mass function requires a revision.

We should stress that neither existing, nor planned space optical astrometry facilities are capable to solve this problem. This is the area where the unique capabilities of KVN or KaVa give us an advantage.

During the main part the project $\sim$40 pairs of sources will be observed KaVA at 43 GHz: a group of 20 pairs within the Galactic plane and within 20° of the Galactic center and a group of 20 pairs beyond 30° of the Galactic plane. VERA will be using dual-beam systeam, while KVN will switch between the sources.

Figure 1: Excessive rms of arc lengths of pairs of nearby sources as a function of galactic longitude and latitude in the vicinity of the the Galactic center (Larchenkova et al. 2017). Units: microseconds. Zones with the excessive rms < 10, 10–20, 20–25, and > 25 μas are shown with different color.



2 Proposed pilot project

In the pilot phase of the project we propose to observe 99 candidate sources selected form the Radio Fundamental Catalogue. All these candidate sources have been detected with VLBI at 8 GHz, but rather few of them were observed at 22 or 43GHz. The candidate sources are from two groups. The first galactic group of sources was selected as 1) $|b| < 1.5°$, 2) $\delta \in [-30°, -5°]$, 3) distance to the second component of the pair is in the range of $[0.35°, 2.00°]$ degrees. There are 44 sources in this group and 105 pairs (some sources form more than one pair). All sources of this group are brighter 10 mJy at 8 GHz. Since scattering in the interstellar medium affects the estimates of correlated flux density at low frequencies, we do not restrict our candidates with flux densities. The second control group of 55 sources was selected as 1) $|b| > 30°$, 2) $\alpha \in [13.5^h, 14.5^h]$, 3) $\delta \in [-30°, -5°]$, 4) 8 GHz flux density $>$ 100 mJy; 5) distance to the second component is in the range of $[0.35°, 2.00°]$ degrees. We select the sources in the control group with the same range of declinations to have comparable atmospheric contribution, otherwise statistics in arc lengths will not be comparable. In order to observe both groups in the same session, we select the sources from the control group in the right ascension range 12–14 hours.

The goal of the pilot phase is to find suitable pairs for further observations. We are going to observe each target source for the pilot phase in at two scans of 6 minutes each at both 22 and 43 GHz. According to the EVN calculator, sources brither 25 mJy at Q-band and 15 mJy at K-band recorded at 4 Gps are supposed to be detected.

The deliverables of the pilot phase of the project will be: a) a list of pairs most suitable for the main phase of the project; b) positions at 2-10 mas level of accuracy; c) correlated flux density at 22, 43 GHz. The results will be made publicly available within one month upon completion of correlation of the last segment.

References

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