1 Introduction

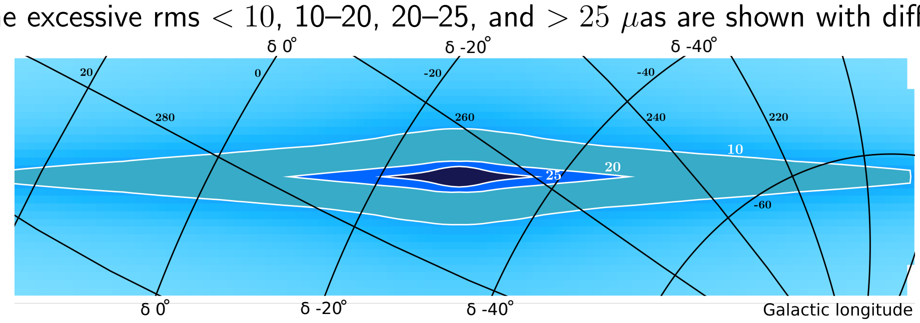
Motion of stars in our Galaxy makes the gravitational field non-stationary. Radio waves propagating in the non-stationary gravitational field deflect and their deflection can be described as a stochastic process. Theoretical simulations based on the modern models of stellar mass function described in Larchenkova et al. (2017) predict the rms of the arc lengths of a pair of AGNs to exceed 25 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 $l < 20^\circ$ and $|b| > 1.5^\circ$ and another group with $|b| > 20^\circ$. The goal of proposed observations is to detect 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 it very unlikely we will have such a 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 is wrong and it 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 VERA+KVN give us an advantage.

For the main of the project we propose to observe 40 pairs of sources with VERA at 22 and 43 GHz in sessions with four 8 hour blocks per session: 20 pairs within the Galactic plane and within 20° of the Galactic center and the a group of 20 pairs beyond 30° of the Galactic plane. We propose to observe 6 sessions per year separated with two months within 5 years, 96 hour per 6-month period.

In order to alleviate systematic contribution of the residual ionosphere, we will observe at two frequencies, 22 and 43 GHz.

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 proposal 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 comparison 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 in at least two scans of 12.5 minutes each at both 22, 43, and 86 GHz (KVN only), 6 minuites per source, per band. The VERA and KVN will be observing in different modes. The KVN will observe in a 8 gpbs mode, recording 2 gbps in 22 GHz, 2 gbps in 43 GHz single polarization and 2 gbps at 86 GHz, both polarizations. Within a scan, the VERA will switch frequency from 22 to 43 GHz at the end of a 6-minute long sub-scan. During every scan the VERA will observe two sources simultaneously with both receivers. The KVN will switch from the first source to the second source and back every 60 second. The KVN observations at 86 GHz are not necessary for the goal of this project, but since high frequency calibrators in the Galactic plane are at a premium, we include recording at 86 GHz just to maximize the output of the instrument. We will run the pilot experiment in the absolute astrometry mode as we did it in the past (Petrov et al. 2009, 2012). We will estimate positions of target sources and determine its correlated flux density at 22, 43, and 86 GHz. Considering that 30 sec is required for 22/43 frequency switching in VERA and assuming 35% losses for slewing and observations of atmospheric and amplitude calibrators, the pilot phase of the project requires $(44 + 55) * (6 + 0.5 + 6) * 2/(1 - 0.35)/60 \approx 64$ hours. We split the observations in 8 blocks of 8 hours centers around LST 16 hour.

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 milliarcsecond level of accuracy; c) correlated flux density at 22, 43 and 86 GHz. The results will be made publicly available within one month after completion of correlation of the last segment.

References

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