Improvement position accuracy of calibrators in the vicinty of the Galactic Center

1 Introduction

Despite of enormous efforts to improve density of calibrators, it is not uncommon to hear that "there is no good calibrator just in the area where I want to observe". This is especially true if planned observations are at high frequencies or in the difficult area. The Galactic center is one of these difficult areas. Scattering in the interstellar medium broadens the source and we loose long baselines. Astrometric accuracy plummets without long baselines. Since the interstellar medium is patchy, it is difficult to predict which areas are strongly affected and which are lightly affected (See Figs. 1–2). Since broadening is reciprocal to square of wavelength, observations at high frequencies is the natural choice for a study of Galactic plane objects. Indeed, our previous work, Petrov (2011), Petrov et al. (2011) showed that we can get decent astrometric accuracy within the Galactiv plane observing at 22–24 GHz. That is why we suggest to re-observe at 24 GHz known calibrators within 12° of the Galactic center which position accuracy is worse than 0.5 mas in order to improve their accuracy and get their images for support of a number of astronomical programs.

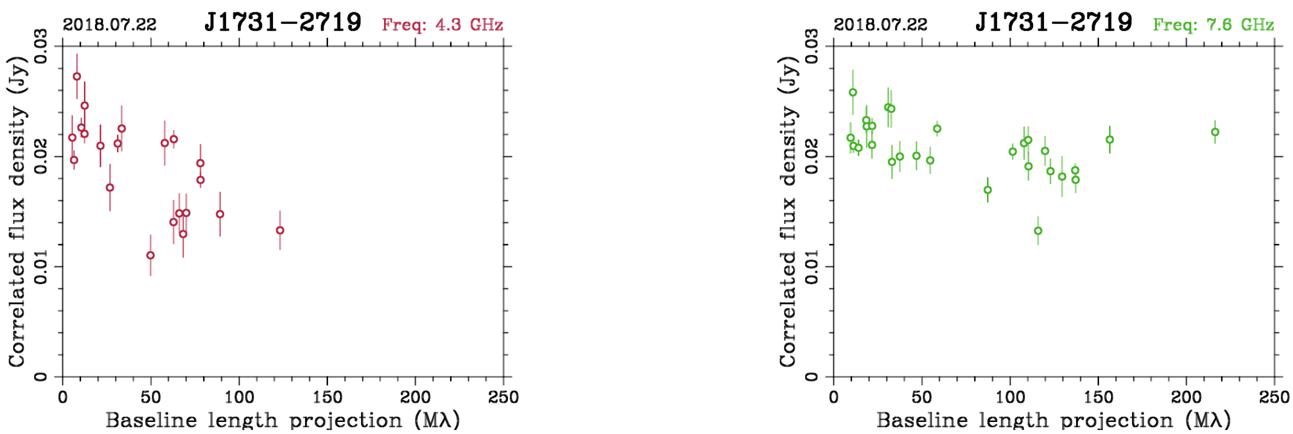

Fig. 1: Unscattered source within 3.49° of the Galactic center.

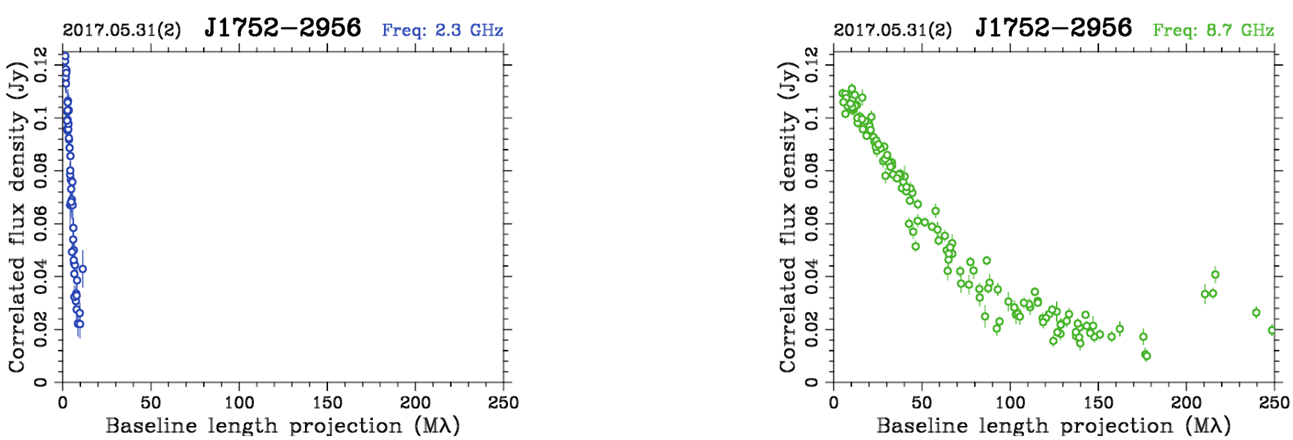

Fig. 2: Broadened source within 1.77° of the Galactic center. No detection at long baselines at 2.3 GHz due to scattering in the interstellar medium.

2 Use case: astrometry with stellar masers

Stellar masers and their line-of-sight velocities can be observed throughout the Milky Way, thus they can be used as probes of both structure and dynamics of the Galaxy. The stellar masers (SiO, OH, H_2O) in evolved stars sample the inner Galaxy and Galactic bulge regions, in contrast to the CH_3OH and H_2O masers in star forming regions used to map out the spiral structure (the BeSSeL project, Reid et al. (2014)), while SiO masers in evolved stars In the Bulge Asymmetries and Dynamical Evolution (BAaDE) survey (Sjouwerman et al. 2014), we are using both the VLA and ALMA to map velocities and positions of 28,000 infrared selected red giant stars in the 43 GHz and 86 GHz SiO maser transitions. These new kinematic probes and their individual stellar properties (e.g., infrared colors) can subsequently be used in dynamical and evolutionary models to significantly improve our understanding of the dynamics, structure and the range of stellar ages in the bulge and inner Galaxy populations.

With the main BAaDE survey, the overall goal is to extract a gravitational potential to model stellar dynamics. The outcome would be greatly enhanced if, in addition to the positions and velocities, we could also supply a distance estimate. For the dynamical studies it is already a success if a distance in front or behind the Galactic center can be determined, i.e., if a distinction can be made between a co-rotating or counter-rotating orbit. As of now, very few of the BAaDE sources have accurate distances derived. Distances based on the kinematics are difficult to derive since the kinematics in the inner Galaxy is not well modeled compared to the disk structure. The Gaia mission have about 2,000 of our sources with distance estimate in the DR2 catalog, however, they are all closer than 4 kpc and do not cover the innermost plane due to obscuration. For the dynamics, reaching the plane is of great importance, as the dynamical signatures are strongest there. To reach the targets located in the bulge and in the central 1 degree of the plane, VLBI parallax observations are needed. Only a few attempt have been done at 43 GHz do perform parallax observations at 43 GHz, are are severly hampered by the challenging calibrationd (e.g., Desmurs et al. 2014).

Due to the high frequency and the resulting small field-of-view, it is very difficult to find good long baseline calibrators at 43 GHz in the Galactic plane sufficiently close to the targets. Most calibrators listed in the Radio Fundamental Catalogs[1] — the most complete astromeric VLBI catalogue to date — are observed only at lower frequencies, 2 to 8 GHz, and extrapolating flux density and structure from a few GHz up to 43 GHz is highly unreliable. The proposed project will allow determination of calibrators at 22 GHz, providing positions with accuracy better 1 mas and images.

3 Use case: astrometry of pulsars close to the Galactic Center

4 Use case: detection of excessive scater in positions due to non-stationarity of th graviational field

5 Proposed observations

We have identified 144 known sources degtected with VLBI in number of observing campaigns. Among them, 38 have position accuarcy better 0.5 mas and we find there no need to reobserve them. Position acuracy of remaining 106 source varies from 0.6 to 22 mas. None of these sources have been observed with VLBI at frequencies higher 8.4 GHz, except J1743-3058 and J1744-3116 (since position accuracy of these two sources is worse than 1 mas, they are kept in the target list). Their total flux density varies from 15 to 300 mJy at 8.4 GHz. These are our targets. We propose to observe them at 23.728–24.24 GHz in three scans each with integration time 180 s. Since some of our targets are week, we

[1] Available at http://astrogeo.org/rfc

request 4096 Mbps mode. Observations will be scheduled in the absolute astrometry mode the same way as the VLBA Galactic Plane Syrvey, project BP125, Petrov et al. (2011): the sequence of sources is optimzied to minimize slewing, each target source is scheduled with a separation of 1–2 hours in hour angle, and a burst of atmospheric calibrators is added every hour. The observations will be split into five 6-hour observing sessions centered around $17^h 45^m$. The data will be analyzed using software package $\mathcal{PIMA}$. We waive the propriatery period.

6 Expected outcome

We will generate the astrometric catalogue of 106 target sources with position accuracy in a range of 0.5–1.0 mas. We will produce K-band images. The proposed observations will be used for contribution to the next edition of the Radio Fundamental Catalogue and as a separate 24 GHz position catalague. The images will be publicly available at the Astrogeo VLBI FITS image database[2]. The final results of the proposed oservations will be publicly available within 90 days of observations of the last segment.

References

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[2]http://astrogeo.org/vlbi_images