KOREAN VLBI NETWORK OBSERVING APPLICATION

VLBI

TERM: 2018B

Proposal ID: V2018B-00
Received Date: 2018/ /

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

2. Authors: (PI on the 1st line)

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***If any student is involved, please give the following information.**
☐ M.S. ☐ Ph.D For thesis? ☐ Yes ☐ No

3. Contact author:
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4. Staff support:
– Observing setup: ☐ None ☐ Consultation ☐ Extensive help
– Post processing: ☐ None ☐ Consultation ☐ Extensive help

5. Proposal type: ☐ Large project(≥100hrs) ☒ Normal proposal(<100hrs)
☐ Joint proposal ☐ If joint, network name:
☐ Resubmission Related previous/current proposal ID:

6. Scientific categories:
☐ Galactic ☒ Extragalactic ☒ Astrometry ☐ Geodesy ☐ Radio transient and pulsars
☒ AGN ☐ Maser ☒ Galactic center ☐ Star Formation ☐ Evolved star

7. Observing type:
☒ Continuum ☐ Spectral line ☐ Phase referencing ☐ Polarimetry
☐ Survey ☒ Multi-frequency ☐ Target of opportunity

8. Observing frequency and polarization:
☒ 22GHz ☒ 43GHz ☐ 86GHz ☐ 129GHz
☐ Single polarization ☒ Dual polarization

9. Observing sessions: ☒ single epoch ☐ multiple epochs
– Total time requested: 36 hrs
– Number of sessions: 6 ; Number of hour each: 6 hrs; Separation: any days
– Min/Max LST (HH:MM:SS): hh1:mm1:ss1 – hh2:mm2:ss2
– Preferred range of dates or dates which are NOT acceptable:

10. Abstract (200 words max, 10 point)

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 predictsthe rms of the arc lengths of a pair of AGNs exceeds 20 microseconds over 5 years if a pair is located within 1.5 degree of the galactic plane at distance closer 25 degrees of the Galactic center. Such a jitter sets a fundamental limit in astrometric accuracy. We propose a program to observe two groups of pairs of sources: one group within $l < 20$ deg and $|b| < 1.5$ deg and another group with $|b| > 30$ deg. The goal of the program 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.
In order to evaluate the feasibility of detection excessive noise in arc lengths, we propose to observe in this proposal a group of 116 candidate sources in order to select from there the best targets for the main program.

VLBI

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

11. Disk usage (recording time/total time): 0.8

12. Recording bandwidth: ☐ 16MHz ☐ 32MHz ☐ 64MHz ☐ 128MHz ☐ 256MHz ☐ 512MHz

Recording rate: ☐ 512Mbps ☐ 1Gbps ☐ 2Gbps ☐ 4Gbps ☒ 8Gbps

13. Spectroscopy only (if you observe more than 4 lines, please attach the additional line information in a separate sheet.)

Items	Line 1	Line 2	Line 3	Line 4
transitions to be observed				
velocity range in LSR (km s^{-1})				
channel bandwidth (kHz)				
rest frequency (MHz)				

14. Number of sources: 116 [If more than 8 sources, please attach separate list.]

15. Name [order of priority]	**Coordinates (J2000)** **RA** (hh:mm:ss.ss)	**DEC** (±dd:mm:ss.ss)	**Freq. (MHz)**	**Band width (MHz)**	**Flux density** **total** (Jy)	**peak** (mJy)	**Time requested (hr)**	**Cal? (Y/N)**
Source name 8								

16. Correlation setup:

– Correlator integration time: 0.2016 (default 0.8096 sec)
– Spectral channels per 16 MHz: 256 (default 128 channel for continuum, 512 for spectral line)

☐ Full stokes correlation ☐ Pulsar gating ☒ P-cal extraction ☐ Multiple phase center

If you need a special correlation setup, please briefly specify here.

17. Special requirements:

– Sites :
– Dates :
– Frequencies :
– etc :

18. Please attach the following items written in English using TeX. The maximum number of pages is 2+1 if you requested less than 100 hours, otherwise it is 4+1. The minimum font size is 10.

– Scientific and technical justifications
– List of publications made by previous KVN observations
– If you requested ToO (Target of Opportunity) observation, please include well-defined trigger criteria.

KVN_Proposal.tex; Version 2016B

The source list. *Beginning…*

	RA J2000	DEC J2000	Freq (GHz)	Flux 8 GHz (mJy)	Int time (min)
J1330−2142	13:30:07.127636	−21:42:01.80437	22/43	0.190	12
J1330−2056	13:30:07.700430	−20:56:16.57700	22/43	0.150	12
J1332−1402	13:32:30.928223	−14:02:13.18644	22/43	0.150	12
J1332−1256	13:32:39.251400	−12:56:15.34353	22/43	0.181	12
J1333−2356	13:33:38.926018	−23:56:25.58101	22/43	0.193	12
J1333−1112	13:33:50.234194	−11:12:51.67477	22/43	0.125	12
J1336−1529	13:36:34.089153	−15:29:48.07088	22/43	0.109	12
J1336−1852	13:36:34.393306	−18:52:41.67342	22/43	0.309	12
J1336−1717	13:36:35.644667	−17:17:27.10141	22/43	0.109	12
J1337−1257	13:37:39.782778	−12:57:24.69339	22/43	4.663	12
J1339−2401	13:39:01.746377	−24:01:14.00630	22/43	0.441	12
J1339−0637	13:39:07.145582	−06:37:04.87865	22/43	0.110	12
J1343−1747	13:43:37.414207	−17:47:55.44622	22/43	0.417	12
J1349−1110	13:49:03.193042	−11:10:00.81934	22/43	0.165	12
J1350−1634	13:50:36.143948	−16:34:49.51470	22/43	0.199	12
J1351−1449	13:51:52.649604	−14:49:14.55697	22/43	0.615	12
J1352−2649	13:52:10.302266	−26:49:28.25630	22/43	0.174	12
J1352−2745	13:52:28.046108	−27:45:07.13257	22/43	0.191	12
J1356−1724	13:56:06.953018	−17:24:31.81750	22/43	0.132	12
J1356−1101	13:56:46.831841	−11:01:29.22770	22/43	0.112	12
J1357−1527	13:57:11.244978	−15:27:28.78691	22/43	0.700	12
J1400−1858	14:00:03.865993	−18:58:11.08613	22/43	0.407	12
J1401−0916	14:01:05.331818	−09:16:31.57125	22/43	0.230	12
J1402−2822	14:02:02.401664	−28:22:25.14458	22/43	0.245	12
J1402−1840	14:02:48.504531	−18:40:47.48959	22/43	0.214	12
J1406−0848	14:06:00.701858	−08:48:06.88060	22/43	0.497	12
J1406−0707	14:06:10.813715	−07:07:02.30969	22/43	0.376	12
J1407−2701	14:07:29.762281	−27:01:04.29279	22/43	0.219	12
J1408−0752	14:08:56.481204	−07:52:26.66654	22/43	0.927	12
J1413−2813	14:13:14.881719	−28:13:37.38808	22/43	0.119	12
J1415−2809	14:15:04.486198	−28:09:54.43148	22/43	0.107	12
J1415−0955	14:15:20.833947	−09:55:58.33098	22/43	0.107	12
J1415−0708	14:15:48.904483	−07:08:07.60548	22/43	0.100	12
J1416−1705	14:16:34.369716	−17:05:45.73283	22/43	0.189	12
J1416−2131	14:16:42.314596	−21:31:55.03299	22/43	0.141	12
J1418−1555	14:18:59.951364	−15:55:37.32365	22/43	0.153	12
J1419−0838	14:19:22.556083	−08:38:32.14082	22/43	0.230	12
J1420−0642	14:20:17.957555	−06:42:08.05119	22/43	0.216	12
J1421−1118	14:21:00.150738	−11:18:20.40330	22/43	0.105	12
J1421−0643	14:21:07.755623	−06:43:56.35613	22/43	0.178	12
J1422−2727	14:22:49.227148	−27:27:56.72406	22/43	0.183	12
J1423−2218	14:23:40.810205	−22:18:17.51614	22/43	0.209	12
J1736−2737	17:36:10.11	−27:37:19.1	22/43	<0.040	12
J1737−2908	17:37:28.40	−29:08:01.9	22/43	<0.040	12
J1741−3004	17:41:57.19	−30:04:45.8	22/43	<0.040	12
J1742−2956	17:42:28.15	−29:56:10.5	22/43	<0.040	12
J1745−3011	17:45:57.0	−30:11:50.9	22/43	<0.040	12
J1746−3214	17:46:15.6	−32:14:00.4	22/43	<0.040	12
J1746−2818	17:46:53.90	−28:18:54.3	22/43	<0.040	12
J1747−295C	17:47:13.02	−29:58:01.8	22/43	<0.040	12
J1747−295A	17:47:55.8	−29:59:48.6	22/43	<0.040	12
J1748−2825	17:48:04.23	−28:25:09.5	22/43	<0.040	12
J1748−2857	17:48:08.93	−28:57:02.9	22/43	<0.040	12
J1751−2525	17:51:51.3	−25:25:00.2	22/43	<0.040	12
J1752−2229	17:52:36.12	−22:29:59.3	22/43	<0.040	12
J1752−2221	17:52:41.58	−22:21:55.4	22/43	<0.040	12
J1755−2144	17:55:07.00	−21:44:39.3	22/43	<0.040	12
J1756−2157	17:56:21.3	−21:57:21.9	22/43	<0.040	12
J1805−2800	18:05:11.55	−28:00:18.2	22/43	<0.040	12
J1806−2031	18:06:13.45	−20:31:45.1	22/43	<0.040	12
J1810−1955	18:10:28.36	−19:55:48.0	22/43	<0.040	12
J1811−1731	18:11:41.5	−17:31:28.8	22/43	<0.040	12
J1812−1824	18:12:42.89	−18:24:17.8	22/43	<0.040	12
J1814−1751	18:14:39.50	−17:51:59.9	22/43	<0.040	12
J1818−1108	18:18:19.26	−11:08:47.7	22/43	<0.040	12

The source list . . . *Continue*

	RA J2000	DEC J2000	Freq (GHz)	Flux 8 GHz (mJy)	Int time (min)
J1731−3003	17:31:46.851162	−30:03:08.93599	22/43	<0.040	12
J1734−2932	17:34:50.139351	−29:32:32.16197	22/43	<0.040	12
J1740−2929	17:40:54.524925	−29:29:50.31594	22/43	<0.040	12
J1743−3058	17:43:17.886827	−30:58:18.65583	22/43	0.081	12
J1744−3116	17:44:23.578229	−31:16:36.29384	22/43	0.515	12
J1744−3036	17:44:34.622808	−30:36:02.38028	22/43	<0.040	12
J1748−2907	17:48:45.683764	−29:07:39.40348	22/43	<0.040	12
J1751−2352	17:51:03.995249	−23:52:15.47860	22/43	<0.040	12
J1751−2524	17:51:51.262525	−25:24:00.06315	22/43	0.207	12
J1752−2336	17:52:06.629303	−23:36:25.71972	22/43	<0.040	12
J1752−3001	17:52:30.950090	−30:01:06.68301	22/43	0.112	12
J1752−2956	17:52:33.108083	−29:56:44.91519	22/43	0.098	12
J1754−2352	17:54:27.372402	−23:52:33.78161	22/43	<0.040	12
J1754−2207	17:54:51.486038	−22:07:42.88661	22/43	<0.040	12
J1755−2232	17:55:26.284535	−22:32:10.61573	22/43	0.275	12
J1756−2807	17:56:49.656204	−28:07:37.69928	22/43	<0.040	12
J1757−2241	17:57:28.874625	−22:41:32.45273	22/43	<0.040	12
J1758−2343	17:58:23.017662	−23:43:12.11615	22/43	0.246	12
J1800−2107	18:00:44.618717	−21:07:36.66045	22/43	<0.040	12
J1801−2056	18:01:39.139743	−20:56:42.05135	22/43	<0.040	12
J1801−2214	18:01:43.549958	−22:14:28.81538	22/43	0.046	12
J1802−2729	18:02:20.991546	−27:29:55.91855	22/43	<0.040	12
J1802−2728	18:02:49.500768	−27:28:04.16732	22/43	<0.040	12
J1803−2748	18:03:16.992547	−27:48:13.98590	22/43	<0.040	12
J1803−2030	18:03:23.723164	−20:30:17.23070	22/43	<0.040	12
J1805−1844	18:05:35.364557	−18:44:42.51708	22/43	<0.040	12
J1808−2124	18:08:06.846816	−21:24:45.06331	22/43	<0.040	12
J1808−1822	18:08:55.515473	−18:22:53.39517	22/43	0.069	12
J1809−1618	18:09:06.939923	−16:18:56.17689	22/43	<0.040	12
J1809−1546	18:09:09.237750	−15:46:52.91867	22/43	<0.040	12
J1810−1626	18:10:39.850661	−16:26:52.93600	22/43	0.054	12
J1815−1836	18:15:30.368319	−18:36:13.27078	22/43	<0.040	12
J1818−1705	18:18:02.902755	−17:05:40.89705	22/43	0.070	12
J1819−1419	18:19:15.636769	−14:19:00.23015	22/43	<0.040	12
J1820−1432	18:20:11.866053	−14:32:11.37900	22/43	<0.040	12
J1820−1111	18:20:23.287524	−11:11:12.26448	22/43	0.156	12
J1821−1224	18:21:23.277941	−12:24:12.93415	22/43	0.037	12
J1822−0938	18:22:28.731953	−09:38:56.47903	22/43	0.060	12
J1823−1437	18:23:36.212572	−14:37:21.60942	22/43	<0.040	12
J1824−1410	18:24:55.346532	−14:10:53.25307	22/43	<0.040	12
J1826−1057	18:26:36.313398	−10:57:19.07610	22/43	0.050	12
J1827−0814	18:27:11.878561	−08:14:14.47421	22/43	<0.040	12
J1828−0912	18:28:56.022072	−09:12:31.10841	22/43	0.067	12
J1829−0650	18:29:47.803722	−06:50:27.18551	22/43	<0.040	12
J1831−0756	18:31:03.673703	−07:56:54.17241	22/43	<0.040	12
J1831−1107	18:31:05.910050	−11:07:21.18185	22/43	<0.040	12
J1832−0610	18:32:42.228041	−06:10:25.38011	22/43	<0.040	12
J1833−0855	18:33:19.581130	−08:55:27.21011	22/43	<0.040	12
J1833−0713	18:33:44.694054	−07:13:41.94794	22/43	<0.040	12
J1833−0711	18:33:54.003536	−07:11:09.43444	22/43	<0.040	12
J1837−0653	18:37:58.032984	−06:53:31.23929	22/43	<0.040	12

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

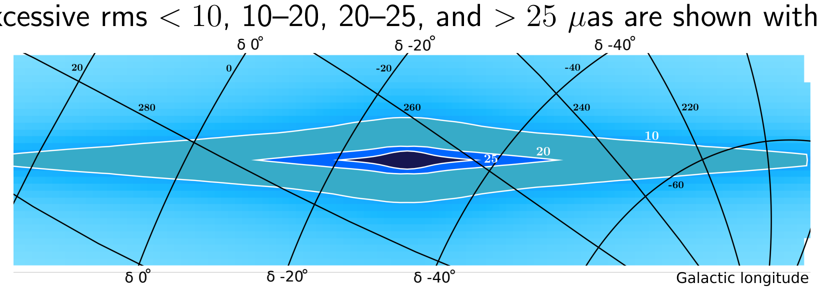
1 Introduction

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 system, 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 116 candidate sources selected form the Radio Fundamental Catalogue. Of them, 93 candidate sources have been detected with VLBI at 8 GHz, but were not 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 74 sources in this group and 181 pairs (some sources form more than one pair). Of them, 23 target sources were detected at K and Q band with the VLA, but were not observed with VLBI. 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 42 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 brighter 25 mJy at Q-band and 15 mJy at K-band recorded at 4 Gps are supposed to be detected.

We found the KVN is best suited for the pilot project because of its superior senstitiviy at 22 and 43 GHz.

3 Expected outcomes and commensal science

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, similar to our previous surveys with VERA and KVN (Petrov et al. 2009, 2012) The results will be made publicly available within one month upon completion of correlation of the last segment. High frequency calibrators are at premium. For instance, they are badly needed for ALMA and for Gould Belt Distance Survey[1]. We expect that many of the target sources after the proposed observation will be sufficiently unresolved for ALMA and VLBA, will have accurately-measured positions, and will be above the 10-sigma antenna-based detection for each ALMA 30-sec calibrator observation using $\sim$40 antennas. The good quality sources will also be added to the ALMA catalog of calibrators used for phase referencing.

References

Larchenkova, T.I.; Lutovinov, A.A.; Lyskova, N.S., (2017) ApJ, 835, 51L, 2017.
Honma, M., Kurayama, T., (2009) ApJ, 568, 717H.
Petrov, L., Honma, M., Shibata, S. M., (2009) AJ, 143, 35P.
Petrov L., et al., (2012) Astron. J., 144, 150.

[1] http://www.crya.unam.mx/~l.loinard/Gould/

Technical justification for “Detection of the background position noise due to non-stationary of the Galactic gravitational field. Pilot project.”

We propose to observe at 22 GHz at 43 GHz, dual-pole mode with 2 IFs 0.512 GHz each. The central frequency is selected to have the best sensitivity.

We will need so-called ANT-files with a priori model computed by the correlator. The correlator output will be analyed with PIMA, Psolve and Difmap.