LBA_Calibrator_Survey-2

OPAL LBA Cover Sheet

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Proposal Details

Previous proposal number	V271
Previous publications	0
Proposal type	Standard
Continuing	No
Scientific categories	Extragalactic
Help required	None

Instrument Information

Antennas requested

- Parkes
- ATCA (single)
- Mopra
- Tidbinbilla (DSS34)
- Hobart
- Ceduna
- HartRAO

Observing mode	Disk recording
Simultaneous ATCA observations	No
Recorder	LBADR
Other information	Astrometry
Correlation location	Bonn

Shipping location Bonn, Address: Contents of disks from ATCA, Ceduna, and Mopra will be transferred electronically to Bonn. Disks from Hobart26, Hartrao, Parkes, and Tidbinbilla will be shipped directly to Bonn from the stations.

Abstracts

Scientific

We request five 24 hour observing sessions at ATCA, Ceduna, Mopra, Hobart, Parkes, Tidbinbilla (and Hartrao if available) for running 8.4 GHz observations to determine coordinates at a milliarcsec accuracy level for 518 flat-spectrum sources in the declination zone [-40, -90]. We will also produce estimates of correlated flux density and source structure. The output catalogue of source positions will be of use for phase-referencing observations at the LBA, as a calibrator pool for the ATCA, ALMA, and SKA, for space navigation, and as a source list for geodetic observations. The success rate of previous observation was 97%. Even considering a conservative success rate estimate of 75%, the pool of known southern calibrators is expected to increase by more than a factor of 2 and the density of known calibrator at the southern hemisphere will match the density of known calibrators in the northern hemisphere. These observations will help to extend a complete flux-limited sample of compact radio sources that currently is limited by declination > -40deg to the whole sky. Our goal is to increase the density of calibrators, so it will match the density in the northern hemisphere.

Outreach

The goal of our project is to improve the map of southern sky in radio waves. Positions of 500 bright compact sources will be determined with the highest accuracy that the modern technology allows. For the first time astronomers will make images of radiogalaxies that are never seen in the northern hemisphere. This observations will help astronomers to complete a census of bright radiogalaxies with active nuclea.

Scheduling

Total time for project **120 hours (previous + this proposal + future requests)**

Allocated time so far **48 hours (all previous semesters)**

OPAL LBA Observations Table

Name	Position			Integration time (hours)	Repeats	Total time	Target type	Band	Polarisations	IFs	Frequencies (MHz)	Bandwidths (MHz)	Transitions	Data rate (Mbps)
	RA	Dec	Epoch											
518 target sources	00:00:00	-90:00:00	J2000	110.0	1	110.0	many sources	3cm	2	4	8400	16		512
116 tropospheric calibrators	00:00:00	-90:00:00	J2000	10.0	1	10.0	many sources	3cm	2	4	8400	16		512

Total time for semester: 120.0 hours

LBA Calibrator Survey

1 Summary

We request five 24 hour observing sessions at ATCA, Ceduna, Mopra, Hobart, Parkes, Tidbinbilla (and Hartrao if available) for running 8.4 GHz (X-band) observations to determine coordinates at a milliarcsec accuracy level for ~ 500 flat-spectrum sources in the declination zone $[-40°, -90°]$. We will also produce estimates of correlated flux density and snap-shot images. The output catalogue of source positions will be of use for phase-referencing observations at the LBA, as a calibrator pool for the ATCA, ALMA, and SKA, for space navigation, space VLBI, and as a source list for geodetic observations.

2 Past observations

In experiment `v230` we have successfully demonstrated [1] the feasibility of precise geodesy and absolute astrometry at the LBA. The proposed project extends the previous projects `v254` and `v271`. To date, three experiments in the framework of these projects were observed and two have been correlated. Among 250 targeted sources, 243 objects have been detected and their coordinates were derived. Estimates of correlated flux densities were also produced. The preliminary catalogue is available at `http://vlbi.gsfc.nasa.gov/lcs/cat`. Formal errors of positions of more than 90% sources are less than 2 mas, and the median uncertainty is 1.1 mas.

3 Why calibrators are needed

A catalogue of compact radio sources with positions known at to an accuracy of several milliarcsec is needed for many applications. Among them are phase referencing for imaging weak objects with VLBI, accurate differential astrometry (for example, for pulsar and maser proper motions and parallax), spacecraft navigation, calibrators for ALMA, targets for space navigation, monitoring the Earth's rotation, and space geodesy.

These observations will also address a long-term scientific goal of proposers for the creation of a homogeneous, flux limited sample of compact radio sources. Currently, the completeness of the sample of compact radio sources in the declination zone $> -40°$ with correlated flux density > 200 mJy at baselines longer than 900 km is estimated at a level of 95% (Kovalev, private communication). The proposed observations will help to extend the complete sample to the whole sky. The **complete** sample will allow generalization of various statistics, such as compactness, the brightness temperature for the core and jet components, the dependence between the angular size of the core-jet region and the redshift, and others, to the entire population of compact radio sources.

4 Why new observations are needed

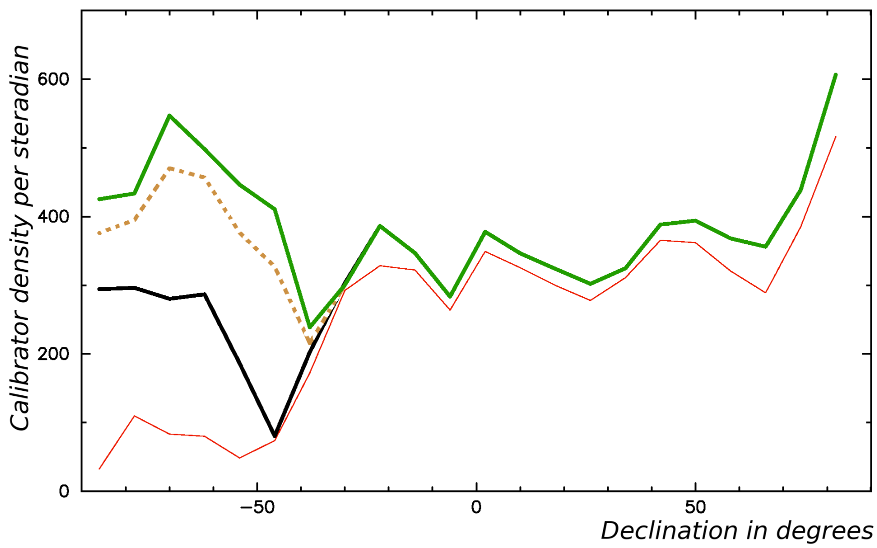
Prior to LBA observations `v254b` and `v271`, only 143 calibrators in the declination zone $[-90°, -40°]$ were known, compared with 721 objects in the declination zone $[+40°, +90°]$. Plot 1 shows the sky calibrator density in 8° declination bins as a function of bin declination. We see the rapid drop of source calibrator density starting with declinations $-30°$ and further south. The probability to find a calibrator within a circle of 2°, 3°, and 4° at any given direction in various declination zones is shown in table 1.

Observations using the VLBA [2, 3, 4, 5, 6, 7] have helped us to create a dense pool of calibrators in the region that the VLBA can monitor, $> -40°$. Owing to `v254b` and `v271` observations, the calibrator sky density in the southern hemisphere improved significantly, but still is much lower than in the northern hemisphere.

Table 1: The probability to find a calibrator within the specified search radius at any given direction in two declination zones. **Column 2009 (cons)** shows predicted probabilities according to a conservative estimate that the probability of detection will be at a level of 75%. **Column 2009 (opt)** shows the predicted probability assuming that the detection rate at all five requested observing sessions will be 100%. The right column shows the probability to find a calibrator in the northern hemisphere.

	Zone $[-90°, -40°]$				$[+40°, +90°]$
Statistics	**2007**	**Now**	**2009 (cons)**	**2009 (opt)**	Now
2° radius	**21.2%**	**46.8%**	**73.3%**	**78.0%**	73.4%
3° radius	**41.2%**	**71.8%**	**94.2%**	**96.2%**	95.0%
4° radius	**60.5%**	**87.1%**	**99.0%**	**99.5%**	99.6%
# objects	**143**	**414**	**873**	**1026**	721

Figure 1: The calibrator source density per steradian in various declination zones. **The thin red line** shows the density in 2007 prior LBA observations, **the black thick line** shows the current density after two sessions v254b and v271a, **the dash orange line** shows the predicted density under a conservative assumption of the detection rate of 75%, and **the upper green line** shows the predicted density assuming 100% detection rate.



5 Proposed observations

In order to address the problem of poor calibrator coverage of the southern hemisphere, we propose five 24 hour observing sessions at 8.4 GHz at ATCA, Ceduna, Mopra, Hobart, Parkes, Tidbinbilla, and Hartrao. **Our goal is to increase the density of calibrators, so it will match the density in the northern hemisphere**. All stations will be observing at 8.4 GHz at four IF channels of 16 MHz each spread over 256 MHz with two bits sampling. ATCA and Mopra will observe at two polarizations, other stations will be observing one polarization. The stations ATCA, Ceduna, Mopra will be utilizing the LBADR disk based recording system, while Hobart, Parkes, Tidbinbilla, and Hartrao will use Mark5. Stations Hobart, Parkes, Tidbinbilla, and Hartrao will record 12 more frequency channels in addition to four IF channels common to all stations. The bits rate at Ceduna will be 256 Mbit/s, at ATCA and Mopra 512 Mbit/s, at Parkes, Hobart, Tidbinbilla, and Hartrao will be 1024 Mbit/s.

The data will be correlated on the geodetic correlator at Bonn. Data from ATCA, Ceduna, and Mopra will be transfered to Bonn via the network, where they will be re-written into Mark5b. The procedure of correlation of experiments with a heterogeneous frequency setup has been polished during processing prior experiments v230, v254b, and v271.

We request any Tidbinbilla antenna, if available, for the improved *uv*-coverage. While the observations do not depend on Tidbinbilla, the extra baselines will improve the accuracy of the solutions. Results of these observations will be of interest for JPL for support of future interplanetary missions and for support of Plank mission.

Candidate flat-spectrum sources in the declination range of $[-90°, -40°]$ from the AT20G and PMN catalogues will be selected on the basis of their probability of being detected using the algorithm developed and successfully tested in [5]. All objects in these catalogues with the flux density extrapolated to 8.4 GHz > 160 mJy and spectral index flatter than -0.5 will be observed.

We will apply the same scheduling strategy that we have successfully applied in `v254b` and `v271`. The sources will be observed in a sequence that minimizes slewing in three scans of 120 seconds each, at least 3 hours apart. Every 1 hour a block of 4 strong sources with precisely known positions and recent maps, so called tropospheric calibrators, will be observed. Tropospheric calibrators will be scheduled in such a manner that each station will observe at least one source at the elevation range of $[5°, 20°]$ (except Parkes), one source at the elevation range of $[20°, 50°]$, and one source at the elevation range of $[50°, 90°]$. The tropospheric calibrators will also serve two other goals: 1) they will tie the resulting catalogue to the ICRF catalogue; 2) they will be used as amplitude calibrators; 3) they will be used for assessing the systemaic errors of source positions.

Final data analysis will be performed at NASA using Calc/Solve software program in a similar way how positions of other 4239 sources have been determined. The expected accuracy of source positions is 1–5 mas. We will be using global GPS maps for alleviation of ionospheric errors. It is important to make these observations while the solar activity is still low.

6 Outcomes

We will publish on the web at `http://vlbi.gsfc.nasa.gov/lcs/cat` preliminary positions from each epoch within 10 days upon completion of correlation. Once the full survey is complete, we will publish the full source list with flux densities and positions and make a web searchable interface to the list.

As a valuable by-product, these observations will also be used for further improving site coordinates and get the first estimates of ATCA, Ceduna, and Mopra velocities.

The full survey will certainly also spur numerous science projects, such as investigating the AT20G population or searching for specific objects such as gravitational lenses. One such example is proposal `v275`, a search for super-massive black holes also being submitted last year.

References

[1] Petrov L., Phillips C., Bertarini A., Deller A., Pogrebenko S., Mujunen A., The Use of the Long Baseline Array in Australia for Precise Geodesy and Absolute Astrometry, Submited to PASA, 2008, http://http://arXiv.org/abs/0809.0627

[2] Beasley, A. J. et al., 2002, ApJS, 141, 13.

[3] Fomalont, E., Petrov, L., McMillan, D. S., Gordon, D., Ma, C. 2003, AJ, 126, 2562.

[4] Petrov, L., Kovalev, Y.Y., Fomalont, E., Gordon, D., 2005, AJ, 129, 1163.

[5] Petrov, L., Yu.Y. Kovalev, E. Fomalont, D. Gordon, 2006, AJ, 131, 1872.

[6] Kovalev, Yu.Y., L. Petrov, E. Fomalont, D. Gordon, 2007, AJ, 133, 1236.

[7] Petrov L., Kovalev Y.Y., Fomalont E., Gordon D., 2008, AJ, 136, 580.