LBA_Calibrator_Survey-3

OPAL LBA Cover Sheet

Name	Email	Affiliation	Country	Student	Available for observations?
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Proposal Details

Previous proposal number	V271
Previous publications	0
Proposal type	Standard
Continuing	No
Scientific categories	surveys and studies of distant galaxies
Help required	None
Used for PhD thesis	Yes

Instrument Information

Antennas requested

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

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, and Tidbinbilla for continuing 8.4~GHz observations for determining coordinates at a milliarcsec accuracy level of 550 flat-spectrum sources in the declination zone [-40, -90]. Our goal is to increase the density of calibrators in the southern hemisphere, so it will match the density in the northern hemisphere. 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.

Outreach

The goal of our project is to improve the map of the 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. Since the majority of radiotelescopes are located in the northern hemisphere, the southern sky is not studied in that level of details as the northern sky. There are still white spots in radio maps. These observations will eliminate remaining white spots, and completeness of maps in radio waves of the southern hemisphere sky will match to completeness of maps of the northern sky. These observations will help astronomers to complete a census of bright radiogalaxies with active nuclea.

Scheduling

Total time for project	**216 hours (previous + this proposal + future requests)**
Allocated time so far	**96 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, and Tidbinbilla for continuing 8.4 GHz observations for determination coordinates at a milliarcsec accuracy level of ∼550 flat-spectrum sources in the declination zone [−40°, −90°]. **Our goal is to increase the density of calibrators in the southern hemisphere, so it will match the density in the northern hemisphere**. 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, 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. In the previous part of this project we observed 422 sources in four 24 hour observing sessions. Among them, 410 objects have been detected, their coordinates were derived, and correlated flux densities were evaluated. The paper is in preparation and will be submitted in Q1 2010 after computation of the ionosphere contribution to group delays will be completed and the study of systematic errors will be finished. The preliminary catalogue of positions and correlated flux densities is available at **http://astrogeo.org/lcs/cat**. Formal errors of positions of more than 90% sources are less than 2 mas, and the median uncertainty is 1.0 mas.

3 Why calibrators are needed

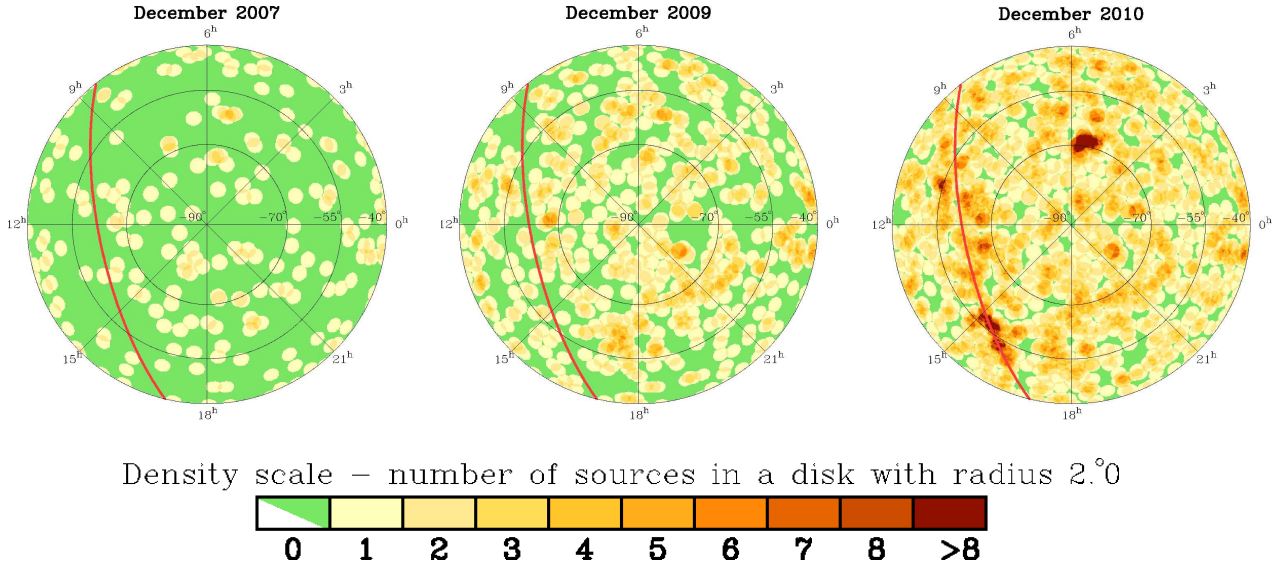
A catalogue of compact radio sources with positions known to an accuracy of several milliarcsec is needed for many applications. Among them are phase referencing for imaging weak objects with VLBI, accurate differential astrometry (for example, for pulsar and maser proper motions and parallax), spacecraft navigation, calibrators for ALMA, targets for space navigation, monitoring the Earth's rotation, and space geodesy. According to [8], in 2008 more than 2/3 of all VLBA observing proposals used phase referencing.

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

Currently, the probability to find no calibrators within 2° degrees from any target in the declination zone [−90°, −40°] is 37%. After analyzing requested observations, the probability to find a field with no calibrator within 2° will be dropped by **a factor of 3** to 11%.

Figure 1: The probability of find a calibrator in a disk of 2° radius of any direction with $\delta < -40°$ a) in December 2007, prior the LBA Calibrator Survey; b) in December 2009 — the present status of the project after analyzing 4 experiments; c) in December 2010 after 5 requested experiments.



5 Proposed observations

In order to address the problem of poor calibrator coverage in the southern hemisphere, we propose five 24 hour observing sessions at 8.4 GHz at ATCA, Ceduna, Mopra, Hobart, Parkes, and Tidbinbilla. Ceduna will be observing RCP 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 the same frequency setup, but in both polarizations. Hobart, Parkes, and Tidbinbilla will be observing RCP using Mark-5B at 8 IF channels spread over 320 MHz. The bits rate at Ceduna will be 256 Mbit/s, at ATCA and Mopra 512 Mbit/s, at Parkes, Hobart, and Tidbinbilla will be 1024 Mbit/s.

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.

The data will be correlated on the hardware 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 v271a–c.

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 > 150 mJy and spectral index flatter than -0.5 will be observed.

We are going to observe more sources near the Galactic plane, $|b| < 6°$. First, in this zone we raise the declination limit to −30°. Second, we reduce the flux density limit extrapolated to 8.4 GHz to 100 mJy. Third, we will scrutinize the preliminary ATCA 20GHz catalogue of

$\sim$ 1700 Galactic plane objects (T. Murphy et al., unpublished) with $|b| < 1.^\circ 5$ from several on-going projects and we will select the sources that a) are known as not extended; b) are not associated with known galactic objects; c) have flux densities at 20 GHz 200 mJy or brighter.

We will slightly modify the scheduling strategy that we have successfully applied in v254b and v271. Each target source will be observed in a sequence that minimizes slewing in three scans at least 3 hours apart, 100–110 sources per 24 hour observing session. Scan duration will be in the range of 2–6 minutes depending on a predicted correlated flux density. 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 systemic 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 4559 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://astrogeo.org/lcs/cat** preliminary positions and estimates of the correlated density from each epoch within 10 days upon completion of correlation.

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.

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, PASA, 26(1), 75–84. 2008. **http://arXiv.org/abs/0809.0627**

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