Newsletter 5

March 2011

PI Report

Tara Murphy and Shami Chatterjee

Welcome to the first VAST Newsletter for 2011. After a quiet period over the Summer/Winter break work is now underway, starting with a "VAST Pipeline" meeting on the 31st of March, around the time this newsletter will be distributed.

This edition has a Western Australian focus, with science updates from Cathryn Trott, a new member of VAST, and a profile of our Working Group 5 Chair Hayley Bignall.

Due to popular demand, we have reduced the amount of material on the Working Group updates, and increased the updates on recent papers that have been published by VAST collaboration members. We welcome contributions on your latest papers for the next edition – it's a great way to publicise your work.

Looking forward to another productive year working on VAST and associated projects.

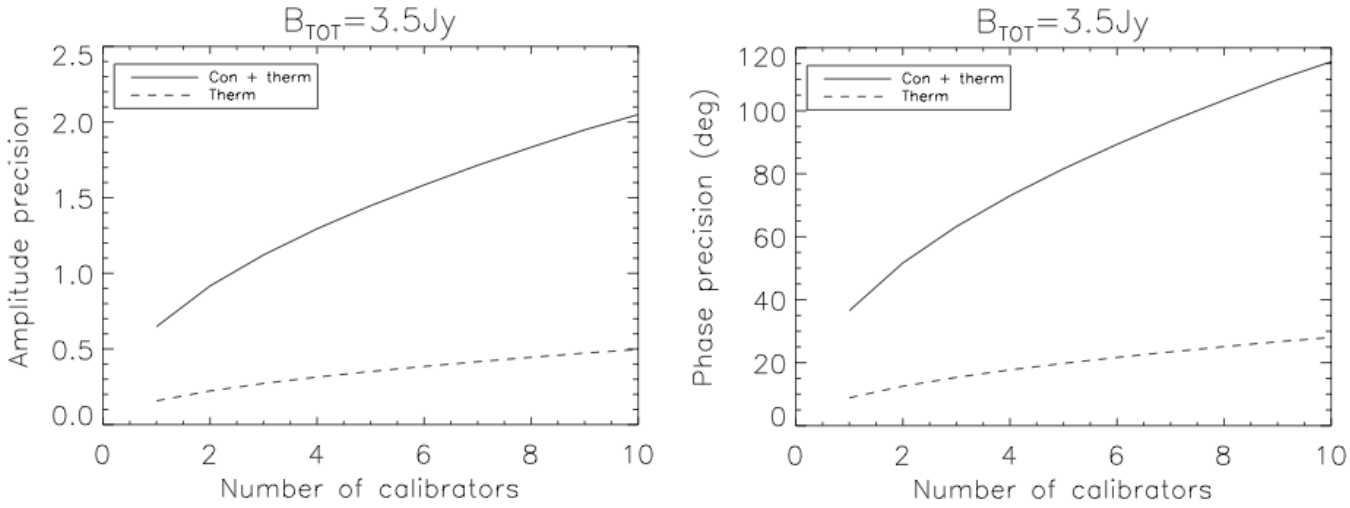
Science Report

Source detection in interferometric visibility data

Cathryn Trott, Randall Wayth, Jean-Pierre Macquart and Steven Tingay.

We have recently published a paper exploring the possibility of performing optimal source detection in visibility space, with a view to designing an optimal real-time slow transient detector for future large-scale synthesis instruments. There were two primary motivations for operating in visibility space.

(1) The timescale of slow transient events range over many orders of magnitude, with different detection techniques likely to be best (from the perspective of detection performance, as well as data availability and ease of implementation) at different scales. For transients with timescales less than, or on the order of, the imaging time of a given array, image-based detection techniques will see a diluted transient signal. In this case, the information carried by the higher time resolution visibility data can be harnessed.



Gain amplitude and phase precision for a single baseline and all frequency channels (total bandwidth of 30.72MHz) of the MWA 32T, as a function of the number of calibrators (total calibrator flux density of 3.5Jy). Curves are shown for thermal noise alone (Therm), and for thermal + confusion noise (Con+therm).

(2) Design of an optimal detector using classical signal detection theory requires an understanding of the underlying distribution of the signal and noise, in order to compare the signal-present and signal-absent hypotheses on the basis of probabilities. Visibility space is a more natural basis in which to describe the noise characteristics of an interferometer: it is closer to the original measured raw data, and doesn't suffer from the structured noise characteristics of a Fourier-transformed image. However, we stress that the classical theory is generally applicable, and optimal detectors can be built in image space.

We proposed a method for designing optimal source detectors using visibility data, building on statistical decision theory. The approach is substantially different to conventional radio astronomy source detection. Optimal detection requires an accurate model for the data, and we presented a realistic model for the likelihood function of radio interferometric data, including the effects of calibration, signal confusion and atmospheric phase fluctuations.

As part of this process, we derived fundamental limits on the calibration of an interferometric array, including the case where many relatively weak "in-beam" calibrators are used. These limits were then applied, along with a model for atmospheric phase fluctuations, to determine the limits on measuring source position, flux density and spectral index, in the general case. An understanding of these fundamental limits feeds into the detection performance we can achieve, but also independently provides insight into the limits of synthesis imaging.

One of the most interesting results from this work was an evaluation of the precision with which the instrument calibration could theoretically be performed when using a finite number of field calibrators (as is planned for the ASKAP and MWA instruments). The figures above show the theoretical maximum precision of the measured amplitude and phase calibration for a particular baseline, as a function of the number of calibrator sources available (where the total calibrator flux is fixed at 3.5Jy) for the MWA 32T. Clearly the precision is degraded as the number of lower flux sources are used. These limits may have implications for the science goals of future instruments.

Finally, we presented an optimal visibility-space detector using realistic models for an interferometer. In an upcoming paper we implement the theory presented in this work, and build a real visibility-space detector, with specific reference to the MWA and ASKAP instruments.

Our paper is available on ADS at:

http://adsabs.harvard.edu/abs/2011arXiv1102.3746T

Profile – Hayley Bignall

Hayley is a Postdoctoral Fellow at Curtin University. She is a member of the Australia Telescope Users Committee and is the chair of VAST WG5.

What are your main research interests?

I am interested in AGN and jet phenomena, and in the use of interstellar scattering as a probe of compact structures - both in the sources (usually quasars) being scattered and in the intervening interstellar medium responsible for the scattering. I am also interested in VLBI, and its use for high angular resolution follow up of some of the interesting "slow" transients that VAST will discover.

What papers are you working on at the moment?

I'm working on a paper for Radio Science based on a presentation I gave last year at the Asia Pacific Radio Science Conference, basically a summary of recent results and planned observations related to interstellar scattering of quasars. I'm involved in some of the MASIV Survey follow up work being done by Curtin PhD student Kevin Koay, which is aimed at determining whether we can detect angular broadening of high redshift quasars in the intergalactic medium, by measuring the suppression of their (Galactic) interstellar scintillation at different frequencies. It turns out there are a lot of complicating effects to model. Kevin has just submitted a data paper and is working on an analysis paper for these observations. Also I'm involved in an SKA memo led by Leith Godfrey, on the high angular resolution science case for the SKA.

What excites you about ASKAP?

During my PhD I was using well established telescopes like ATCA and the VLA. It's quite exciting to witness a new, large telescope being built, using new technologies. Apart from that, ASKAP's wide field of view will make it sensitive to rare, exotic transient events that will be interesting to follow up with high angular resolution, to try and understand the underlying physics of the phenomena. Also, being able to survey a large fraction of the sky repeatedly will help to understand the Galactic ISM structures responsible for propagation effects such as extreme scattering events.

What is the main challenge for Working Group 5?

We will have to figure out how best to access the data for the various types of VAST science, both for real-time and for archival or statistical analysis. VAST aims to study a large range of phenomena on a large range of timescales. Are existing software tools suitable or will specialised software need to be developed?

What do you enjoy outside astronomy?

I enjoy rowing, hiking, yoga, going to the beach, snorkelling, reading, seeing the world, and enjoying good food, drinks and company. I also recently started playing squash, which I am enjoying but still pretty hopeless at.

Working Group Reports

For this edition we have summarised all of the VAST milestones which have deliverables that we need to submit to CASS in 2011.

#0.15 Submit VAST survey paper
(led by Tara and Shami)

#1.11 Write memo reviewing continuum compact source-finding
(WG2, led by Paul Hancock)

#2.3 Provide ASKAP Computing a list of features and suggested changes to the Duchamp source-finder
(WG2, led by Paul Hancock)

#4.5 Plan BETA Observing program
(WG4, led by Simon Johnston)

#5.3 Update data archive requirements document
(WG5, led by Hayley Bignall)

Finally, the overall deliverable for 2011 which is an end-to-end demonstration of the VAST transient detection pipeline (WG5, led by Tara Murphy and David Kaplan). Check the notes from the March 31st meeting for updates on this.

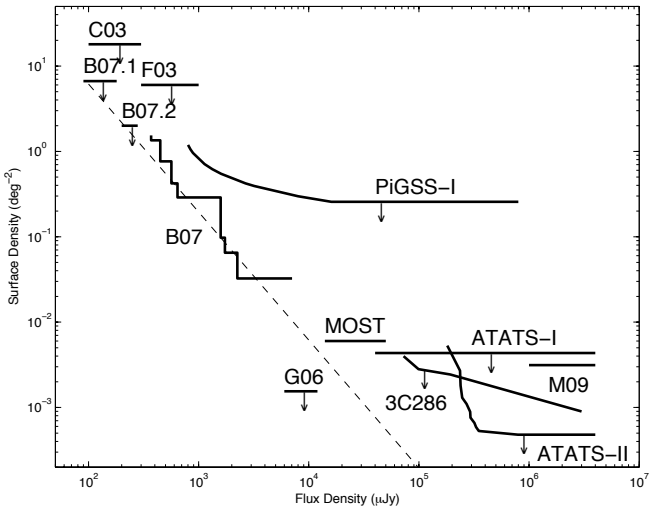
We also have to give feedback to CASS on the Science Processing Document by April 22nd. Please send me any feedback you have on this document (available on the wiki).

News and Updates

The ATA Twenty-centimeter Survey

Steve Croft, Geoff Bower, and the ATA Team

Steve Croft and colleagues have published their second paper on the Allen Telescope Array Twenty-centimeter Survey (ATATS). ATATS is a pilot survey based on observations obtained during early ATA science operations in 2009, intended to verify the performance of the telescope as well as to search for transients. The paper has been posted on arXiv at http://arxiv.org/abs/1102.2227



Cumulative two-epoch source density for radio transients as a function of flux density. See paper for references. The upper limits from the new paper (ATATS2) appear to rule out an astronomical origin for the Matsumura 2009 transients.

The paper compares catalogs made from 11 epochs of snapshot images of a 700 sq. deg. region centered on the Bootes deep field, and also compares the catalogs to NVSS. The 90% completeness limits of the single-epoch catalogs range from 98.6 to 232 mJy. No transients brighter than 350 mJy were seen, corresponding to an

upper limit of 6e-4 transients / sq. deg., for transients with characteristic timescales of minutes to days. This strongly rules out an astronomical origin for the ~1 Jy sources reported by Matsumura et al. (2009), based on their stated rate of 3.1e-3 / sq. deg (see figure).

The ATA Team is applying the techniques developed for ATATS to the analysis of the ATA Pi GHz Sky Survey (PiGSS), and continues to share lessons from ATA operations and science with the VAST collaboration.

Archival VLA transients survey

Geoffrey Bower and Destry Saul

We present a transient survey in the field of 3C 286 from archival VLA observations at 1.4 GHz. This survey faces the challenge of dynamic range limited snap shot observations. Detections in consecutive epochs provides a successful method for rejecting spurious sources. No transients are found in the 1852 epochs examined. The upper limit on the transient rate is comparable to that found with ATATS and contradicts the published rates from Nasu Observatory surveys.

http://adsabs.harvard.edu/abs/2011ApJ...728L..14B

LWDA All-sky Survey

T. Joseph W. Lazio and the LWDA team

We have recently published a paper on an all-sky survey for transients with the Long Wavelength Demonstrator Array (LWDA) on time scales comparable to that targeted by VAST, though at a much lower frequency (74 MHz vs. approximately 1000 MHz for VAST). No radio transients were found. Nonetheless, it presents a few lessons for VAST. Within the VAST team has been discussion of how to handle the data from the shortest antenna separations. The LWDA had quite small antenna separations, with the result that it was sensitive to large-scale (non-variable) structure on the sky, illustrating the possible processing considerations for VAST. The resulting upper limit on the rate of transients found by the LWDA is of interest to compare with the VAST results in terms of understanding possible different populations of transients. Finally, the LWDA survey represents exploration of the transient radio sky in the spirit of VAST.

http://adsabs.harvard.edu/abs/2010AJ....140.1995L

Upcoming Meetings

Supernovae and their Host Galaxies

Powerhouse Museum, Sydney, June 20 to 24 2011

http://www.aao.gov.au/southerncross

New Horizons in Time Domain Astronomy

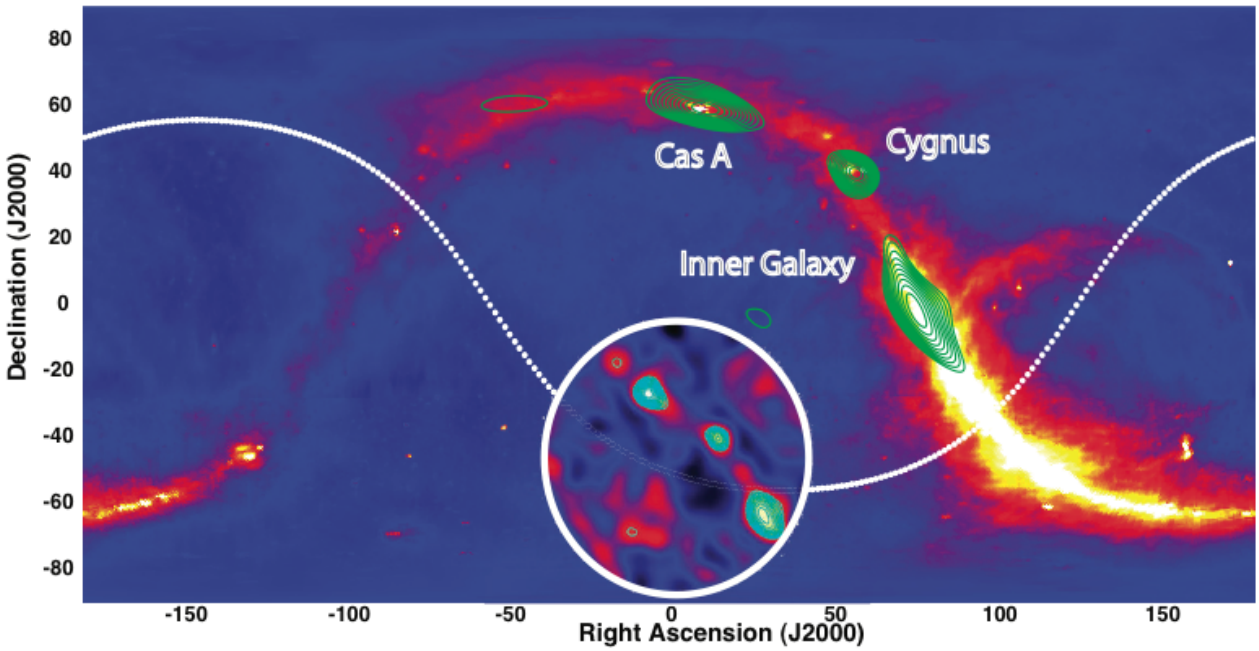
University of Oxford, September 19 to 23, 2011

http://www.physics.ox.ac.uk/IAUS285

Very Wide Field Surveys in Light of Astro2010

STSCI, June 13 to 16, 2011

http://widefield2011.pha.jhu.edu/



Comparison of an all-sky LWDA snapshot image at 73.8 MHz (green contours) with the 408 MHz all-sky image (colour) from Haslam et al. (1982). See paper for full caption.