VAST Newsletter 10

June 2012

PI Report

Tara Murphy and Shami Chatterjee

The big news this edition is that the VAST paper we submitted to PASA last month has now been reviewed and will be accepted after minor corrections. It will be great to have a summary of the project available for people to reference. Thank you to everyone who contributed!

The other big news is that all 36 of the ASKAP antennas have been assembled at the Murchison Radio-astronomy Observatory (MRO) in WA. Engineering commissioning will now commence.

We have recently established a collaboration with the US Virtual Astronomical Observatory to work on a project developing VO-compatible tools to access VAST and EMU data. This involves a number of VAST team members including Joseph Lazio, the VAO Project Scientist. This work will start over the next six months.

This week is the Astronomical Society of Australia Annual Scientific Meeting. Good luck to all of the VAST postdocs and students who are presenting talks or posters!

Finally, welcome to a new VAST team member, Davide Burlon who has started a postdoctoral position at the University of Sydney, working with Tara on radio detections of Gamma-Ray Bursts.

Science Report

Multi-wavelength Constraints on Pulsar Populations

Robert Wharton, Shami Chatterjee, J. M. Cordes, J. S. Deneva, and T. J. W. Lazio

We have been working with Cornell graduate student Robert Wharton to investigate pulsars and radio transients in the Galactic center and have recently published our initial results (2012, ApJ, 753, 108). The detection of radio pulsars within the central few parsecs of the Galaxy would provide a unique probe of the gravitational and magneto-ionic environments in the Galactic center (GC) and, if close enough to Sgr A*, precise tests of general relativity in the strong-field regime.

While it is difficult to find pulsars at radio wavelengths because of interstellar scattering, we conclude that the payoff from detailed timing of pulsars in the GC warrants a concerted effort. To motivate pulsar surveys and help define search parameters for them, we constrained the pulsar number and spatial distribution using a wide range of multi-wavelength measurements (see Figure 1):

- the five known pulsars within 15' of Sgr A*;
- non-detections in high-frequency pulsar surveys of the central parsec
- radio and gamma-ray measurements of diffuse emission;
- a catalog of radio point sources from an imaging survey;
- infrared observations of massive star populations in the central few parsecs;
- candidate pulsar wind nebulae in the inner 20 pc; and
- estimates of the core-collapse supernova rate based on X-ray measurements.

Under current observational constraints, the inner parsec of the Galaxy could harbor as many as ~100 active radio pulsars that are beamed toward Earth. Such a large population would distort the low-frequency measurements of both the intrinsic spectrum of Sgr A* and the free-free absorption along the line of sight of Sgr A*.

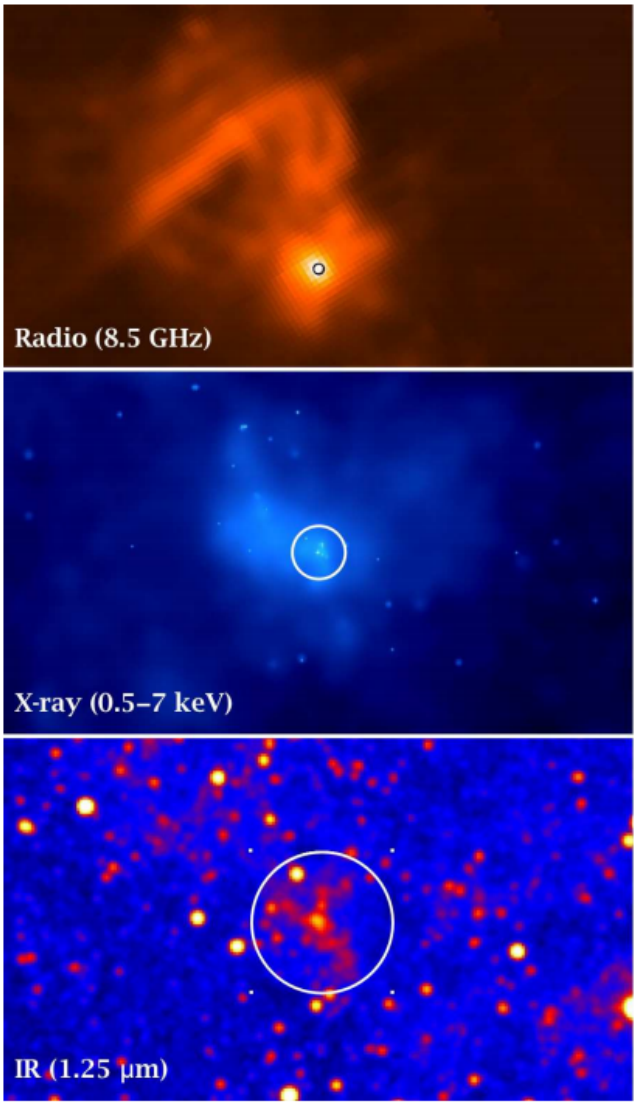

Figure 1: Views of the inner GC region at radio, X-ray and infrared wavelengths. In each panel a circle with radius 25" is centred on Sgr A*.

Profile – Stuart Ryder

Stuart is the Australian Gemini Scientist, managing the Australian Gemini Office hosted by the Australian Astronomical Observatory. He is involved in several VAST projects focusing on radio supernovae.

What are your main research interests?

I'm interested in understanding the progenitors to core-collapse supernovae (CCSNe), to see if we can uniquely match particular classes of massive stars (Wolf-Rayet, Luminous Blue Variable, red supergiant, etc.) to the apparent plethora of supernova sub-types (Type IIP, IIL, Ib, Ic, IIb,...).

In a few recent, nearby CCSN events we have been used HST and ground-based imaging of the host galaxy before the star exploded to derive the progenitor star's final luminosity and colour, from which the initial mass can be inferred.

Radio observations allow us to take a different approach: the expanding blast-wave rapidly probes the star's mass-loss history in reverse, and from this we can deduce what the most likely progenitor was and whether it has a binary companion.

What papers are you working on at the moment?

Together with Christopher Stockdale at Marquette University I am working on a paper that compares the radio light curve properties for various sub-types of CCSNe. We have gathered these over several years with the ATCA and EVLA. I am also working on a paper that provides spectroscopic evidence from Gemini that the progenitor system to the Type IIb SN 2001ig was a pair of Wolf-Rayet stars, something which we predicted on the basis of our ATCA light curves.

What excites you about ASKAP?

The ability to conduct the first blind census of radio emission from nearby (<~50 Mpc) core-collapse supernovae. We still don't know what fraction of all CCSNe give rise to prompt radio emission, since we have to be selective about which ones to trigger follow-up on with the ATCA and EVLA. ASKAP will provide that, and may even reveal supernovae hidden by so much dust that they would not be discovered in optical surveys. I have found a few heavily-reddened CCSNe in Luminous Infrared Galaxies using laser guide star adaptive optics on Gemini, but these appear to be just the tip of the iceberg. We need both infrared and radio surveys to help us tie down the CCSN rate, which is a very direct measure of the star formation rate.

What are the main challenges for your work?

CCSNe brighten and peak earliest at higher frequencies, so by the time they become visible to ASKAP it may be too late to follow them up properly at higher frequency with the ATCA. Also, spatially resolving the supernova from any nuclear and diffuse emission from the host galaxy may be hard. Nevertheless we have been able to show that individual CCSN events can be

observed within the galaxy's integrated flux (see VAST Newsletter No. 6) so all may not be lost.

What do you enjoy outside astronomy?

I love bushwalking in and around Sydney, snorkeling here and on my frequent visits to Hawaii, and cooking BBQs at home. Although it is astronomical in nature, I confess to being addicted to total solar eclipses, having been on 8 expeditions in the past 20 years. I have been privileged to spend a quarter of an hour standing in the Moon's shadow. Somehow that never seems to be enough, so in November I'm off to far north Queensland to try and catch the next one!

News and Updates

Detecting Tidal Disruption Events

Steve Croft

I attended a workshop in Madrid in June 2012 on "Tidal Disruption Events and AGN Outbursts". There was much discussion of observations of candidate tidal disruption events (the destruction of a star passing close to a supermassive black hole) as well as models for the accretion of the stellar material and the resulting dramatic increase in flux from the galaxy nucleus. Distinguishing these events from other forms of variability in active galactic nuclei is challenging, though. It is clear that a multi-wavelength approach can help, and that surveys that have the potential to find large numbers of TDEs will be necessary to determine the underlying rate of such events, as well as the other parameters of the progenitor systems (mass and spin of the black hole, characteristics of the star, formation of jets, emission processes, time evolution, and so on).

TDEs are important for understanding AGN accretion and outflows, probing otherwise quiescent supermassive black holes, and determining stellar populations and dynamics in the inner regions of galaxies.

I presented a poster with the latest results from the Allen Telescope Array Pi GHz Sky Survey (PiGSS) – in particular, from hundreds of observations of four deep fields from a paper soon to be submitted – that represent some of the most sensitive upper limits on the TDE rate. These upper limits are very close to optimistic predictions of the TDE rate in the radio, and so modest increases in sensitivity or area covered may start to detect TDEs in significant numbers in blind surveys.

If these optimistic predictions are correct, VAST will detect thousands of TDEs, providing an excellent opportunity for a comprehensive study of their statistics, light curves, and (from multi-wavelength matches) their host galaxy properties. VAST will also provide light curves for about 250,000 AGN, shedding light on accretion processes in a wide range of situations.

Searching for Infant Supernovae

Stuart Ryder, Chris Stockdale, Davide Burlon, & Paul Hancock

Among other goals, VAST aims to provide the first unbiased census of core-collapse supernovae (CCSNe) by allowing us to match radio detections against optically-discovered CCSNe. We may also detect new radio CCSNe that could have gone undetected in the optical or infrared due to significant amounts of dust. Every CCSN discovery is valuable for tying down the current rate of massive star formation in the Universe. However without solid information about the late-time evolution of CCSNe at ASKAP frequencies our ability to model the detection rates in ASKAP simulations is compromised.

Our ATCA NAPA program C1473 aims to achieve early (within 1 week) detection and follow-up monitoring of radio emission from southern CCSNe within 30 Mpc. We will target frequencies above 5 GHz where the emission peaks earliest. In cases where no source is detected after one or two epochs, then no further follow-up is attempted. If mass-loss had slowed or ceased in the centuries prior to explosion, then the radio emission may take some weeks or months to "turn on" (SN 1987A being a case in point); thus we still do not know what fraction of CCSNe ultimately give rise to radio emission, and therefore had mass-losing progenitors.

To address this problem we applied for and were granted 6x12 hrs of ATCA time in June 2012 to image the sites of 14 CCSNe from the past 6 years in 12 southern host galaxies within 30 Mpc at frequencies of 1-3 GHz, and search for evidence of late-time radio emission. By pairing adjacent galaxies and observing each pair over 12 hours we attained fairly complete uv-coverage for each, and reached an rms noise ~0.02 mJy/beam.

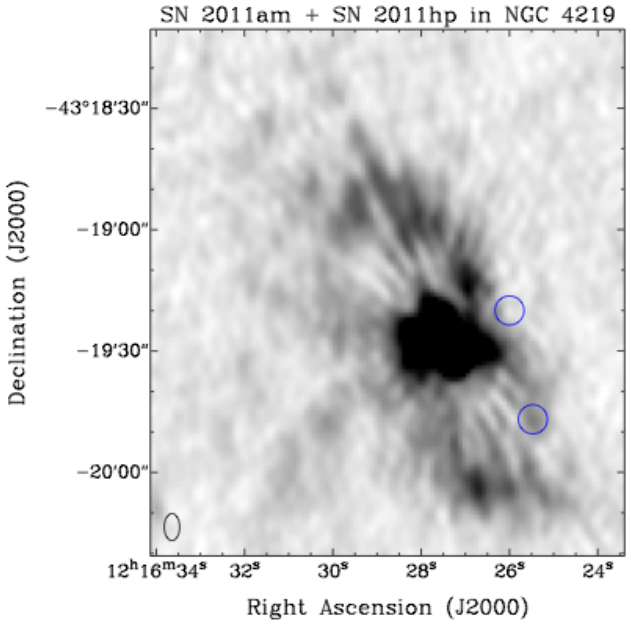

Figure 2: ATCA observations of NGC 4219 at a frequency of 2.7 GHz, with the locations of SN 2011am (west of nucleus) and SN 2011hp (southwest of nucleus) marked by open circles.

Reduction of the data, which are heavily affected by interference, is still ongoing. The best candidate detection so far is for the Type Ic SN 2011hp, which we were initially unable to detect with the ATCA at 9.0 or 5.5 GHz a week after discovery (Ryder et al. 2011, ATel 3764). The figure shows NGC 4219 at a frequency of 2.7 GHz, with the locations of SN 2011am (west of nucleus) and SN 2011hp (southwest of nucleus) marked by open circles. The radial artifacts are due to the strong nuclear emission from NGC 4219. This and other potential radio counterparts detected in our survey will be re-imaged at a later date to confirm their flux is changing as expected.

Scintillation of High Redshift AGN

J. Y. Koay, Hayley Bignall, J-P Macquart, Roopesh Ojha and collaborators

The fraction of compact active galactic nuclei that exhibit interstellar scintillation at radio wavelengths, as well as their scintillation amplitudes, have been found to decrease significantly for sources at redshifts $z > 2$.

The results of our work suggests that the VAST goal of "direct detection of baryons in the intergalactic medium" may be difficult to achieve, as we found no evidence of a redshift dependence of scatter broadening in the MASIV sample. However given a larger number of sources at $z > 3$ it may still be possible to detect scatter broadening at high redshift, or at least obtain tighter upper limits. Also with VAST it may be possible to look for scatter broadening of quasars lying behind the ISM of nearby galaxies, based on statistics of scintillation in the Galactic ISM. See our recently accepted ApJ paper for more information:

http://arxiv.org/abs/1206.5053

A companion paper publishing the optical and spectroscopic identification of the full MASIV sample has also been submitted to ApJ.

BL Lac PKS B1144-379: Extreme Scintillator

Simon Ellingsen and collaborators

Our recently accepted ApJ paper discusses an AGN with unusually long period (8 days) ISS induced variability. This was discovered due to the high-cadence, long-term monitoring with the Ceduna 30m. VAST will investigate the area of phase space for many more sources with much greater sensitivity and so reveal many more sources of this nature. For more information see:

http://arxiv.org/abs/1206.6914

Student Project: VLA Archival Searches

Cornell undergraduate student Ani Chiti has been working with Wharton, Chatterjee, Cordes, and Lazio on radio transients in the Galactic center. As part of his summer research program, he expects to constrain the rate of transients at timescales from 10 seconds to several minutes using archival VLA observations, and to further establish limits on longer term transients as well. We expect extensive collaboration with other VAST members during the later stages of this project.

VAST @ Conferences

Duncan Galloway

In January this year I attended the "Physics of Astronomical Transients" meeting in Aspen where I presented an updated version of the VAST poster. This meeting offered an excellent coverage of some of the candidate sources that we might expect to see with ASKAP, as well as encompassing the wider view of X-ray, optical and even gravitational wave transient programs.

Most recently, I visited Hannover to attend the Gravitational Physics and Astronomy Workshop, hosted by the AEI. I gave a talk on the status of ASKAP and MWA, and prospects for gravitational-wave follow-ups with these instruments. Rob Fender also gave a nice talk on the status of LOFAR and MeerKAT.