VAST Newsletter 11

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PI Report

Tara Murphy and Shami Chatterjee

A few quick updates for this Newsletter issue:

* After achieving first fringes and demonstrating phase closure on a three-PAF baseline system in August, ASKAP was officially declared open on 5th October 2012.

* On the CSIRO side, Lisa Harvey Smith has taken over as Project Scientist. We look forward to working with her, especially as BETA commissioning work ramps up.

* 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.

* Shami adds: Tara has not one but *two* big news items. First, she and James Curran welcomed the newest member of the VAST team, Thomas Murphy Curran, on 8th July 2012. Don't miss the photo on the back page. And then, in a very well deserved bit of recognition, Tara has just been awarded the prestigious Young Tall Poppy award for New South Wales. Congratulations, Tara!

Science Report

What was that? Towards an automated classification of transients

S. G. Djorgovski (Caltech)

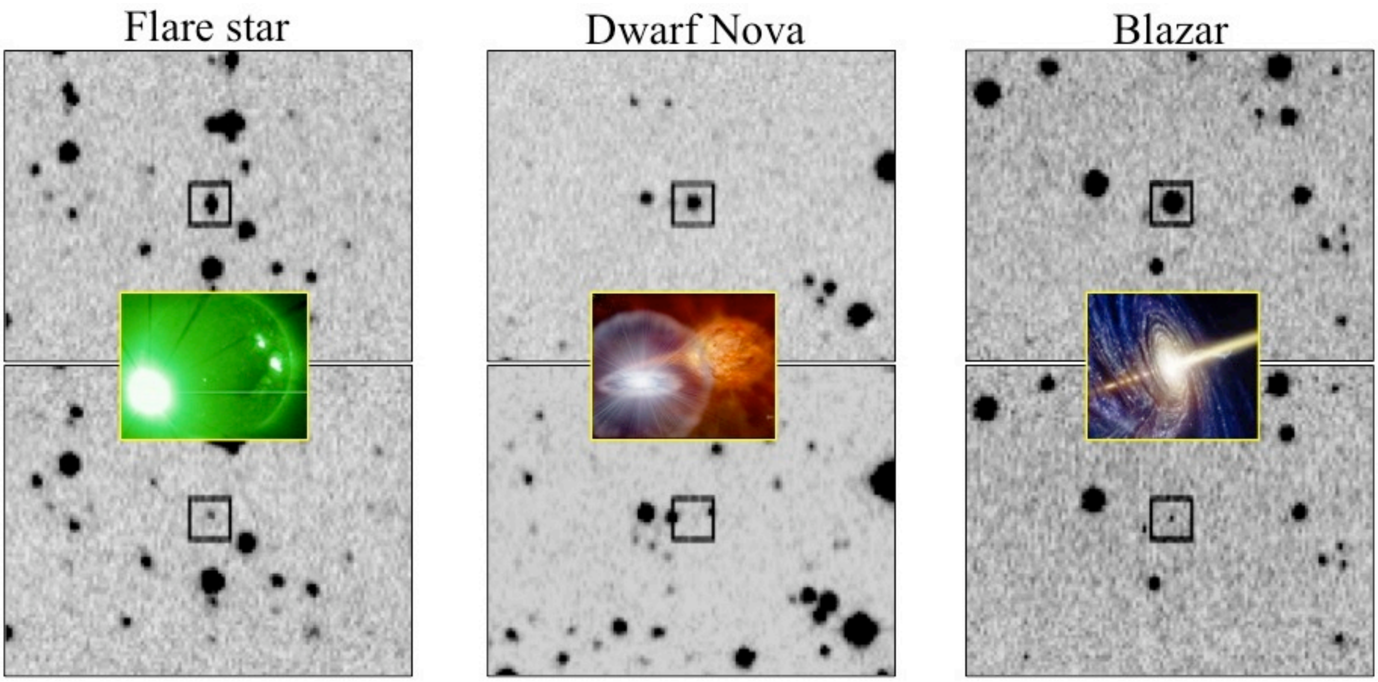
Exploration of time domain is an exciting and rapidly developing area of research, and it promises to become even more so, as new surveys across the full range of wavelengths start to deliver rich new data streams. VAST is an excellent example, since the faint, variable radio sky is still a relatively poorly explored domain. While synoptic sky surveys can discover transient events and variable sources, their physical interpretation is where the science is. In most cases, getting a full scientific benefit requires targeted follow-up observations, especially optical spectroscopy. These usually represent a limited resource, and should be used wisely: not all transients are of an equal scientific value, and not all of them can be followed. Thus, a rapid and robust classification of transient events is a critical need, especially when it comes to a prioritization of events for the follow-up observations. Given the expected data rates, human classification is simply impractical, and an automated approach is necessary.

This is a highly non-trivial problem: the initial survey data are limited, the available archival information is also sparse and heterogeneous, and there is a premium on making a rapid classification in order to follow the interesting events while they are still "hot". The Caltech-JPL group (S. G. Djorgovski, M. Graham, A. Mahabal, C. Donalek, A. Drake, M. Turmon, B. Moghaddam, and numerous students) has been tackling this challenge for several years now, using the event streams from the optical sky surveys, first the Palomar Quest Sky Survey (http://www.astro.caltech.edu/~george/pq/) and now the Catalina Real-Time Transient Survey (http://crts.caltech.edu/). Some of the experience gained there is now being deployed to solve the challenge of the classification of radio transients from VAST. For a brief overview, see, for example, Djorgovski et al. (IEEE eScience 2012; http://arxiv.org/abs/1209.1681). A separate, but related effort is being conducted by K. Wagstaff and her team at JPL.

In most cases, radio light curves by themselves would not contain sufficient information for a meaningful classification, and multi-wavelength archival and contextual information is needed. Given the heterogeneity and incompleteness of the data, Bayesian methods may be suitable for this task, since independent priors can be constructed for every observable, and combined in a statistically sound fashion. One such method is Bayesian Networks; they allow for combining of different kinds of observables, e.g., magnitude changes in some bandpass over some time period, colors, proximity to a nearest galaxy, etc. The initial results are very promising, and will be described in a forthcoming paper (Mahabal et al., in preparation).

Another approach uses 2-dimensional distributions of magnitude changes over different time intervals: for each pair of measurements (m_i, t_i) and (m_j, t_j), we compute (Δm_{ij}, Δt_{ij}). As the new flux measurements come in, we accumulate a 2D histogram in the {Δm, Δt} plane, and compare it to a set of templates for a variety of known types of transients, e.g., supernove of different types, CVs, blazars, etc. Note that we do not assume any particular start time for the event, as it may or may not be well defined. Different metrics are used for the comparison of these histograms, allowing for the determination of the best-fit type at every step. The quality of the classification improves as more measurements arrive. We are currently expanding this approach to use triplets of sequential measurements, which generates 4D histograms. This promises to be a much more powerful classifier that can be applied in radio as well as in the visible (or any other wavelength regime), although at a higher computational cost.

Finally, we have been experimenting with ways of encoding the contextual information from images and past flux histories, by harvesting human pattern recognition skills and domain expertise, using crowdsourcing techniques, and turning them into scalable algorithms. These are still the early days, but some form of a human-machine collaborative discovery may well be the path in the future.



Examples of transient events from the Catalina Real-time Transient Survey (CRTS). Images in the top row show objects that appear much brighter that night, relative to the baseline images obtained earlier (bottom row). On this basis alone, the three transients are physically indistinguishable, yet the subsequent follow-up shows them to be three vastly different types of phenomena: a flare star (left), a cataclysmic variable powered by an accretion to a compact stellar remnant (middle), and a blazar, flaring due to instabilities in a relativistic jet (right). Accurate transient event classification is the key to their follow-up and physical understanding.

Profile – Davide Burlon

Davide Burlon completed his PhD at the Max Plank Institute for Extraterrestrial Physics, before starting a postdoctoral research position at the University of Sydney.

1) What are your main research interests?

I have been involved primarily in research regarding the formation or accretion onto black holes. Accretion is the way we know black holes are not really...black, but they shine in all kinds of light. I have worked on the high energy emission produced when super-sized, highly spinning stars die and produce black holes of a few solar masses in a Gamma-ray Burst. I also worked on the highly energetic light coming from more stationary, supermassive black holes that reside in the active nucleus of galaxies.

2) What paper/s are you working on at the moment?

I am leading a paper on active galaxies. It has long been known that the high energy photons from supermassive black holes are somewhat related to the radio emission: I am currently working on how local black holes "talk" these two languages at the extreme sides of the electromagnetic spectrum. I contributed to a paper (currently being refereed) that presents the most up-to-date population synthesis model for Gamma-ray Bursts and shows something unexpected: the "faster" the ejecta of a GRB are, the narrower is the cone in which these are emitted!

3) What excites you about ASKAP?

I guess that the most exciting things are the Rumsfeld-ian unknown-unknowns. As I once heard Dr. Bryan Gaensler say, more than the huge amount of information on things we know (or think we understand reasonably well) that will soon start flowing in, it is the unexpected discovery that might be just behind the corner that excites me. It has often been the case that while scientists were looking for something they serendipitously found something else: this is what I am looking forward to seeing. Hopefully we will open up a new area of research.

4) What are the main challenges for your work with ASKAP?

The most challenging aspect of working with this new facility is to plan the mid-to-long term goals of my research. Building a scientific project on a telescope that is going to reach operational capacity after the end of your contract is quite a test. This is particularly difficult for me as I come from a different environment and a different field in astronomy, and I am not working on the more technical aspects of the facility.

5) What do you enjoy outside astronomy?

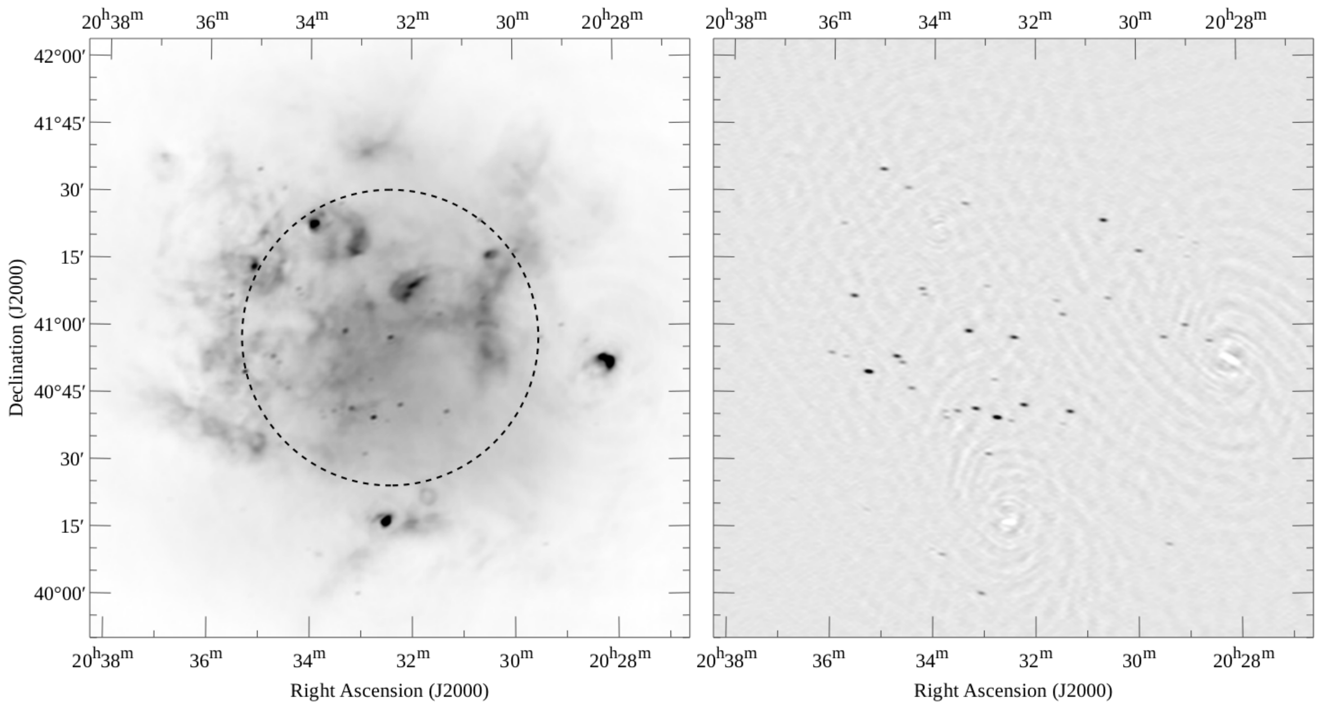
Even if I spend many hours per day in front of a monitor, I tend to stare at the screen during evenings as well because I am somewhat a political junkie and a skeptic. Fortunately my wife Ilaria is incredibly patient and has similar interests. I follow many blogs that take their time to be read. This is just during the week though! We spend weekends outside, to hike in the Blue mountains or swim... I am eagerly looking forward to my first attempts at surfing.

Thesis Report – Peter K. G. Williams

Exploring the Dynamic Radio Sky with the Allen Telescope Array

In August I completed my PhD at UC Berkeley, marking a milestone in - but not an end to! - several years of studies of the dynamic radio sky performed with the Allen Telescope Array and my adviser Geoff Bower.

The main component of my dissertation (available online at http://newton.cx/~peter/dissertation/) is a large ATA survey for slow Galactic radio transients called ASGARD, for which the observing is completed and analysis is ongoing. In the subset of the data that we've processed, no transients are found, but we demonstrate our imaging and source detection techniques, analyse



ATA images of the Cygnus X-3 region made for ASGARD. The left panel shows a deep image of the field, while the right panel shows a single epoch that has had large-scale structure subtracted from the u-v data. The color scales in the two panels are different.

source variability, and derive limits on transient areal densities. The figure above shows an example of how the ASGARD pipeline subtracts large-scale galactic structure to ease detection and analysis of the compact sources in each field. The first ASGARD paper has been submitted to ApJ.

One of my interests has been the software infrastructure for radio transient searches. The dissertation also includes chapters presenting a framework for writing interferometric analysis tools with MIRIAD and Python (published as 2012 PASP, 124, 624) and discussing the commensal observing system used to perform ASGARD observations (published as ATA memo #89). Finally, my dissertation shows how the capabilities of modern radio interferometers such as the ATA can be used in practice. I used the ATA's broadband coverage to test predictions about the radio spectra of star-forming galaxies (published as 2010 ApJ, 710, 1462) and multiwavelength lightcurves of the microquasar Cyg X-3 to examine the origin of its gamma-ray emission (2010 ApJL, 733, L20).

I'm now at Harvard, starting a postdoc with Edo Berger, where I'll study the radio flares of low-mass stars and continue my work on ASGARD, VAST, and whatever other radio transient projects I can get my hands on!

Back Page: A New VAST member

Thomas Murphy Curran is currently working on the Starfleet Academy pre-K curriculum, but he is expected to take on VAST responsibilities soon.