The Ephemeral Universe with Widefield Low Frequency Arrays

12-14 November 2013

The Curtin Institute of Radio Astronomy,

1 Turner Avenue, Technology Park, Bentley WA

http://www.caastro.org/event/2013-transients

ABSTRACTS

Tuesday 12 November 2013

Prof. Don Melrose, University of Sydney

Coherent Emission in Astrophysical Plasmas (Invited)

Prof. Linqing Wen, University of Western Australia

Real-Time Detection of Binary Coalescence and its Electromagnetic Follow-up Observations

We present the status and future prospect of real-time low-latency detection of gravitational waves (GWs) from coalescing binaries of neutron stars and black holes. The implications to the electromagnetic follow up observations of these GW events especially in optical and radio wavelength will be discussed.

Dr. Wojciech Lewandowski, Kepler Institute of Astronomy, University of Zielona Gora

The consequences of the existence of Gigahertz Peaked Spectra pulsars in low frequency observations

The Gigahertz Peaked Spectra (GPS) pulsars are a new class of objects, that show a maximum of flux density in their spectra at the frequencies around 1 GHz or above. This of course translates to positive spectral index at low frequencies, which means that the observed flux decreases as the frequency goes lower. The most probable explanation for this phenomenon is probably an interaction of the pulsar radiation with the matter of peculiar environments those objects usually adjoin. Whatever the reason, since this group of objects may comprise up to 10% of the whole pulsar population, their existence should be taken into

account when planning low-frequency search surveys or other observing campaigns at these frequencies. On the other hand, since most of GPS pulsars we know so far have relatively high disperssion measures, at lower frequencies they undergo extremely high scattering which makes any attempts of flux density measurements by standard means very hard or even impossible. The only way to overcome that problem - which is crucial to the study of the GPS phenomenon itself - is by using the interferometric imaging method to measure their flux densities.

Prof. Ron Ekers, CSIRO

High Energy Particles (Invited)

Transient pulsed radio emission from cosmic ray airshowers is becoming increasingly interesting. I can give some background on the relevant high energy particle astronomy, on the techniques needed for nsec time scale pulse detection, and the potential for using dense wide FoV wide bandwidth arrays such as MWA.

Prof. Don Melrose, University of Sydney

Interpretation of cosmic ray radio emission

Dr. Michael Johnson, Harvard-Smithsonian Center for Astrophysics

Scintillation (Invited)

Dr. Mark Walker, Manly Astrophysics

Sgr A* eats G2 - implications for scintillations

The interaction between the G2-cloud and Sgr A* is an event that will be closely watched over the next year or so. The nature and origin of G2 are controversial topics, but taken at face value the data suggest that planetary-mass gas clouds are commonplace in the central regions of our Galaxy. I will describe how G2 might have appeared before it fell under the influence of Sgr A*: a cold, dense and highly durable molecular cloud. In isolation such clouds can be practically invisible, but their interaction with the diffuse ISM should be detectable if they move supersonically. Strong radio-wave lensing can arise at the surface of a cloud, where high densities of ionised gas may be found. And in its wake we can expect filamentary streams of ionised gas and H2 snowflakes, both of which will scatter radio waves.

Dr. Artem Tuntsov, Manly Astrophysics

Strongly anisotropic scintillations from the dusty ISM?

Some Intra-Day Variable sources, and pulsars displaying parabolic arcs, show evidence for strong anisotropy in the scattering material - practically 1-Dimensional structures in fact. We have modelled the scattering as a purely 1D power-law of electron-density fluctuations, finding that the resulting parabolic arcs and multi-band IDV light-curves are consistent with available data. The models which best match the PSR and IDV data correspond to similar physical structures, but placed much further away in the PSR case. However, the implied gas-pressure and magnetic stresses are much higher than expected for the ISM. Interstellar dust, on the other hand, is pressureless and often appears in filamentary structures. Can dust, rather than ionised gas, be responsible for IDV and parabolic arcs?

Prof. Matthew Bailes, Swinburne University of Technology

FRBs, and recent work with MOST (Invited)

Dr. Evan Keane, Swinburne University of Technology

Detecting highly-dispersed bursts with next-generation radio telescopes

The recent discovery of 10 or so Fast Radio Bursts (FRBs) has been a pleasant surprise. The FRB progenitors are highly-energetic, cosmological in origin and not easily explained as any currently known source. To truly understand the origin of these bursts, and address questions as to their usefulness as cosmological probes, we need to find more, to illucidate their luminosity and redshift distributions, and to observationally characterise them better, i.e. improving positional localisation, measuring polarisation properties and issuing rapid alerts for multi-wavelength followups. Here I present estimates for the discovery rate of FRBs for a number of current and next-generation radio telescopes operating at different sky frequencies and in different modes, i.e. pulsar-type and imaging-type observations. A number of telescopes will be able to combine impressive sensitivities, manageable practical difficulties (wrt scattering and dispersion smearing) with a high Tobs*FOV product so that FRB discoveries should become numerous. I will also briefly discuss different search methodologies for fully exploiting the data from these telescopes.

Dr. Keith Bannister, CSIRO

A population model of fast radio bursts

There are now about 10 of the so called fast radio bursts in existence (many of which are yet to be published). I will describe a simple model for the population of FRBs and show constraints on the luminosity function, and volume rate of FRBs derived from the currently published bursts.

Dr. Simon Johnston, CSIRO

An update on FRB detections from the HTRU survey

Ms. Emily Petroff, Swinburne University of Technology

Searching for Fast Radio Bursts at intermediate latitudes (Invited)

The High Time Resolution Universe (HTRU) Survey is an ongoing project at the Parkes Radio Telescope studying the radio sky at 64Âµs resolution. Analysis of only a fraction of the survey at high latitudes has yielded a population of Fast Radio Bursts (FRBs) thought to lie at extragalactic distances. These bright pulses appear to be non-repeating and are likely cataclysmic in nature; all bursts are highly dispersed with DMs ranging from 550 - 1103 cm^{-3} pc. Based on these detections, the overall rate of FRBs has been estimated at 10,000 per sky per day! I have searched a second section of the HTRU data set - medium latitude pointings at |b| < 15 degrees - for FRB events. If initial rate estimates are correct we might expect between 3 and 10 events to exist in the entire medium latitude portion of the survey. No such events have been found in my analysis. The non-detection of FRB events at medium latitudes gives backing to an astronomical origin, as RFI events would be expected isotropically throughout the survey, and suggests that Galactic effects must be more closely considered and modifications to our predicted rate may need to be made.

Wednesday 13 November 2013

Dr. Jason Hessels, ASTRON / University of Amsterdam

Pulsars and Fast Transients with LOFAR (Invited)

Prof. Scott Ransom, National Radio Astronomy Observatory

The All-Sky GBT 350MHz Pulsar Surveys (Invited)

Dr. Ewan Barr, Swinburne University of Technology

Accelerated acceleration searching and the GPU revolution

In high time-resolution radio astronomy the speed at which we can analyse observed data is often a limiting factor in the pursuit of new science. This is particularly true in case of the search for new millisecond pulsars (MSP) in binary systems. The discovery of these systems -- notable for their uses as unparalleled natural laboratories for tests of gravitation, elements in a Galaxy spanning gravitational wave-detecting interferometer and tracers of stellar binary evolution -- is notoriously difficult due to the fact that we must search for them not only in position, dispersion measure and spin frequency space, but also in acceleration (or orbital template) space. In the past this has been a prohibitively resource-intensive exercise, requiring vast amounts of time on large computing clusters. However, the advent of cheap and useable graphics processing units (GPUs) has allowed for a giant leap in processing capability. The use of GPUs has allowed us to not only vastly increase the parameter space in which we search for binary pulsars, but also develop real-time searching software for both pulsars and other fast transients such as fast radio bursts (FRBs) and rotating radio transients (RRaTs). In this talk I will present the latest developments in GPU-based pulsar/transient searching from Swinburne and look at the application of these systems to past, current and future data sets.

Dr. Paul Ray, US Naval Research Laboratory

Observations of Pulsars with the Long Wavelength Array

Dr. Tara Murphy, University of Sydney

Exploring the transient radio sky with ASKAP and the MWA (Invited)

Dr. Wes Armour, University of Oxford

GPU based real-time signal detection for radio transients using ARTEMIS

Astrophysical radio transients are excellent probes of extreme physical processes originating from compact sources within our Galaxy and beyond. Radio frequency signals emitted from these objects provide a means to study the intervening medium through which they travel. Next generation radio telescopes are designed to explore the vast unexplored parameter space of high time resolution astronomy, but require High Performance Computing (HPC) solutions to process the enormous volumes of data that are produced by these telescopes. This talk focuses on the GPU aspects of a combined software/hardware solution (code named ARTEMIS) for real-time searches for millisecond radio transients. I will give an overview of the software pipeline and its take-up, then on the intricacies of accelerating the signal processing using GPUs. I will present performance comparisons from two de-dispersion algorithms. The first is a GPU based algorithm, designed to exploit the latest NVIDIA GPU technologies. The second algorithm is CPU based and exploits the new AVX units in Intel Sandy Bridge CPUs using Intel Intrinsic instructions. I will conclude with future development directions for ARTEMIS and the challenges posed by the SKA.

Dr. Nadia Kudryavtseva, ICRAR / Curtin

Slow transients with the MWA

I will talk about blind search of transient and variable sources in the 30 degrees field centered at the Pictor A source. The observations were performed at 154 and 185 MHz between March 2010 and September 2011. A total of 116 snapshots were analysed spanning more than 7.5 hours of MWA 32T prototype. A few sources showed a significant variability on timescales of hours and few years. I will present the first detection of a slow transient source with MWA, MWA J0618-5515 which was detected in images with long integration. The source reaches 6 Jy on a timescale of one year. Possible identification of this transient will be discussed. I will also present recent results of the ongoing key science program "Search for transient and variable sources in the EOR fields".

Dr. Nathan Clarke, ICRAR / Curtin

Tardis-MWA – A fast transients detection system for the MWA

Dr. Robert Braun, SKA Headquarters, Manchester

The Design and Science Performance of SKA-Low (Invited)

Progress on refining the design of the SKA1-Low facility together with an assessment of the resulting scientific capabilities will be summarized.

Dr. Andrew Faulkner, Cambridge University

SKA Low Frequency Aperture Array Design (Invited)

The presentation is of a design for a very large, 250,000 antenna, aperture array covering 50-650MHz is discussed here. This is one of the major developments for Phase 1 of the Square Kilometre Array radio telescope, to be deployed between 2017 and 2019. Essential to the efficient design of the array are a single very wide-bandwidth log-periodic antenna and low cost, medium range RF over fibre system. This results in a system design that can have minimal electronics at the antenna and all the digital processing for the entire array in a single, large processing “bunker”□. This is very cost effective, flexible in configuration and easiest operationally for ongoing maintenance. Further, there is the opportunity to house other parts of the SKA-low telescope: e.g. correlator, master clock, telescope management and post processing facilities. The aim is to have individual solar powered antennas to minimize interference issues and save infrastructure costs. The beamforming will be entirely in the digital domain using devices predicted for 2017/8. Considerable flexibility is given by the innovative use of high speed commercial data switches, which enables selectable station sizes and tuning for specific science experiments. The entire system uses technologies that are available or projected in the near future.

Dr. Cathryn Trott, CAASTRO/ICRAR/Curtin

Prospects for detection of FRBs with the MWA and SKA

The discovery of six high-redshift Fast Radio Bursts (FRBs) at ~1400 MHz from the Parkes radio telescope suggests that FRBs may occur at a high rate across the sky. The Murchison Widefield Array (MWA) operates at low radio frequencies (80-300 MHz) and is expected to detect FRBs due to its large collecting area (~2500 m^2) and wide field-of-view (FOV, ~1000 square degrees at nu=200 MHz). We compute the expected number of FRB detections for the MWA assuming a source population consistent with the reported detections. Our formalism properly accounts for the frequency-dependence of the antenna primary beam, the MWA system temperature, and unknown spectral index of the source population, for three modes of FRB detection: coherent; incoherent; and fast imaging. We find that the MWA’s sensitivity and large FOV combine to provide the expectation of multiple detectable events per week in all modes, potentially making it an excellent high time resolution science instrument. Deviations of the expected number of detections from actual results will provide a strong constraint on the assumptions made for the underlying source population and intervening plasma distribution. We extend the analysis to form predictions for SKA-Low, including interesting aspects of the instrument's large fractional bandwidth.

Dr. Jean-Pierre Macquart, CAASTRO/ICRAR/Curtin

Transients detection rates and instrument design

Dr. Laura Spitler, Max-Planck-Institute for Radio Astronomy, Bonn

FRB searches with Arecibo

Prof. Rob Fender, University of Southampton

The perspective from the transients SWG

Dr. Ilse van Bemmel, ASTRON

More science with SKA-low (Invited)

The SKA will consist of three elements, in which SKA-low covers the frequency range from 50 to 350MHz. As an aperture array, the SKA-low has many features which are not available to dish instruments, such as a wide field-of-view, multi-beaming, multi-directional observations and fast re-pointing. This provides enormous potential for new discoveries in the dynamic universe, but also opens up new parameter space in other fields of astronomy. In my talk I will present the non-transient science with SKA-low: Epoch of Reionization, Cosmic Dawn, HI at high redshifts and continuum surveys. I will discuss the discovery potential of SKA-low for these cases, the motivation for some design choices, as well as the underlying challenges. In addition, I intend to briefly highlight a few suggested changes that are being discussed, and the consequences for the current design.

Thursday 14 November 2013

Dr. Randall Wayth, CAASTRO/ICRAR/Curtin

The V-FASTR fast transients project

I will give an overview of the V-FASTR project which is a commensal search for fast radio transient events using the VLBA.

Dr. Gemma Anderson, University of Oxford

GRB Follow-up with the Arcminute Microkelvin Imager (AMI)

The early detection of multi-wavelength radiation from gamma-ray bursts (GRBs) is essential for refining our understanding of the physical nature of the jets and surrounding environments of these extremely energetic events. While early time optical and X-ray follow-up has been obtained for many GRBs, the early time radio signature (within the first few hours post-burst) from such events have not been well sampled. It is only in the last few years that robotised prompt GRB follow-up programs have been implemented in the radio domain. Here I present the initial results from the GRB radio follow-up program being conducted with the Arcminute Microkelvin Imager (AMI). Through this program we are obtaining prompt follow-up of an unbiased sample of GRBs in an attempt to detect reverse shock radio emission and perhaps associated fast radio transients. This robotised program is capable of being on target within 5 minutes allowing us to probe the radio properties of GRBs within the first hour post-burst, an under explored region of the GRB time domain. Through this program our AMI observations have yielded the earliest ever significant detection of a GRB at radio wavelengths. Through this, and subsequent AMI observations of the same GRB, we have obtained the best known sampling of reverse shock emission from a GRB at radio wavelengths. The prompt observations obtained from this non-biased sample of GRBs will therefore allow us to investigate the percentage of GRBs likely to produce reverse shocks, enabling us to explore the necessary environmental properties required to produce this type of emission. We are also conducting prolonged AMI monitoring of GRBs up to 10 days post-burst to search for forward shock emission. Using these resulting AMI light curves in tandem with LOFAR observations has allowed us to place valuable constraints on parameter space to narrow down GRB emission models. The AMI GRB follow-up program is therefore an important test bed for investigating the GRB radio transient rates and signatures that we might expect to detect with the future high and low frequency SKA pathfinders.

Dr. Ramesh Bhat, CAASTRO/ICRAR/Curtin

High-time resolution, simultaneous pulsar observations with the MWA and Parkes

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Dr. Steve Ord, CAASTRO/ICRAR/Curtin

Current and future data capture and offline processing possibilities with the MWA; how, when and why?