2024 MWA Project Meeting Book of Abstracts

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MWA Project Meeting

Wednesday, 28 August

Welcome

Steven Tingay | Director's Overview

MWA Data Access and Processing Workshop

Mouriyan Rajendran | An Introduction to MWA ASVO and Data access

- Introduction to the data portal
- Browsing observations and utilizing the TAP service
- Submitting and managing jobs and data
- Various services provided:
    - Web interface
    - Command line clients
    - Virtual Observatory (VO) TAP Service
    - Processed MWA Data
- Data collections and delivery options
- Priority assignment for users downloading data
- Tips and tricks for efficient data exploration

Dev Null | How to process MWA visibilities

There are very few instruments with the capabilities that MWA provides. However, unlocking the full potential of the MWA archive requires bespoke software to deal with some of its idiosyncrasies. In this workshop, participants will be given the tools to download, preprocess, calibrate and image almost any correlated MWA observation.

Starting with a representative sample of raw MWA visibility files (Phase I & II, Legacy correlator & MWAX), we will preprocess those raw files with Birli, demonstrate how to perform quality analysis and flagging, calibrate with hyperdrive, and image with wsclean.

The software for this workshop has been fully containerised and can run offline on any machine capable of emulating linux-x86 (this includes arm64-based macs running the latest Docker). The demo website will be updated with more details closer to the event about what you need to download in order to prepare your machine for the demo.

Dev Null [they/them] is a contributor to many MWA software projects, including the Birli preprocessor, and hyperdrive calibration suite. Dev is currently working with the Epoch of Reionisation team on a data quality analysis pipeline which has processed ~600 hours of MWA

EoR observations from 2013 to present. This work is part of the Australian SKA Regional Centre's efforts to support precursor instruments.

Invited Speakers

Thomas Schulthess | Thoughts on the future of large-scale radio astronomy data processing

Jade Ducharme | U.S.-Based Research on Mitigating Radio Frequency Interference for MWA Data

For the first part of my talk, I will be focusing on different radio frequency interference (RFI) mitigation techniques currently being developed at Brown University and the University of Washington. At Brown, my home institution, our group's efforts are directed towards developing both traditional and machine learning (ML) algorithms to detect RFI for MWA data. On the traditional side, we have developed a novel RFI flagging method based on the $\chi 2$ metric from redundant calibration, which has been shown to identify a significant amount of RFI in the Australian DTV7 band that popular flaggers such as SSINS and AOFlagger fail to detect. We have also applied the watershed algorithm used by HERA as an additional RFI detector for MWA data. On the ML side, we are developing a U-Net model that processes waterfall plots to generate flag arrays. This project shows significant promise, with the overall goal being to implement a weak supervision framework that intelligently combines flags produced by traditional flagging algorithms in order to provide robust labels to the U-Net. This will enable it to detect RFI independently flagged by various traditional methods, which may not always overlap.

At the University of Washington, researchers are exploring the image-space representation of RFI. Preliminary results indicate that some forms of stationary RFI, often overlooked by traditional flagging methods, could be more easily detectable in image space. These findings suggest the need for new approaches to RFI flagging based on MWA data images.

For the second part of my talk, I will present my ongoing PhD research, which aims to develop a new method for estimating an RFI emitter's altitude using near-field corrections. Near-field corrections are used to change an interferometric array's focal distance from infinity to a location much closer, in the so-called near field of the instrument. The data used to conduct this work is a two-minute 2013 Phase I MWA observation, during which an RFI-emitting object briefly crosses the field of view. This emission can be visualized in image space using an imaging software such as WSClean. In addition to producing the image, WSClean also conveniently outputs a source list containing the right ascension (Ra) and declination (Dec) coordinates of all sources it identifies during the cleaning process. By combining the RFI-emitting object's Ra and Dec with a variable focal distance parameter, which represents the distance between the object and the MWA array, we can apply near-field corrections to bring it into focus. This technique aims to fully localize an RFI emitter, with the ultimate goal being to subtract or peel it from the observation altogether.

Applying this novel technique to the observation in question, we estimate the RFI emitter's altitude to be 8.53±0.06 km. Combining this measurement to the object's angular displacement as a function of time, also tracked using WSClean, we are able to estimate its speed to 579±4 km/h. These findings allow us to confidently classify the previously unknown RFI emitter as an airplane.

Greg Sivakoff | Canada, the MWA, and CANDIAPL

Engineering and Operations

Greg Sleap | MWA Data, Archive and Systems Update

In this presentation I will briefly update the collaboration on the MWA Archive, MWA ASVO and systems.

Yajun Wu | The status of SHAO-MWA Ph3 receiver

The Shanghai Observatory of China (SHAO) and MWA have collaborated on the development of Phase III digital receivers. The on-site installation of the prototype has been completed and observation testing is currently underway. This report will introduce the functional requirements, hardware and software design, related test results of this digital receiver. And some other digital backends based on this will be reported, including broadband pulsar terminals and spectral line backend, as well as preliminary observation results

MWA Project Meeting

Thursday, 29 August

Solar, Heliospheric and Ionospheric Science (SHI)

Rohit Sharma | Overview of Solar Science Group Activities from MWA

2024-25 has been an exciting year for the solar science group of the MWA. We have had significant developments on both fronts - developing novel calibration and imaging algorithms and pipelines and using them to pursue novel science. On the techniques front, we have made strides towards making state-of-the-art spectro-polarimetric snapshot images and are working towards automating this procedure in a robust pipeline. On the science front, our explorations have ranged from the weakest non-thermal emissions ever detected from the quiet sun to the strong radio emissions associated with the drivers of space weather, and they yield fascinating insights and discoveries. We are close to commissioning triggered solar observations, which is expected to substantially improve our efficiency at capturing interesting solar events. A large part of our recent work has focused on polarimetric investigations of active solar emissions. Detecting and analysing heliospheric Faraday rotation signatures of coronal mass ejections is another focus area of our work. This talk will present an overview of the different aspects of work we have been pursuing over the past time, along with our plans for the near future.

Ferry Lanter | Improving MWA Ionospheric Corrections Using Small Satellites

This talk presents a cost feasible remote sensing solution that we have developed to aid and improve the calibration of Murchison Widefield Array (MWA) measurements for ionospheric errors using small satellites. For polarimetry, a crucial step in the calibration of MWA measurements involves removing the polarization error due to ionospheric Faraday rotation (FR) with a sufficiently high precision to extract astronomical information. However, current calibration algorithms to correct for ionospheric FR are inherently limited by the accuracy and uncertainty of Global Navigation Satellite System based ionospheric total electron content (TEC) models and publicly available geomagnetic models on which they rely. As a direct consequence, polarization corrections currently have a rotation measure (RM) uncertainty of ~0.1rad/m2. This yields an insufficiently precise calibration solution to enable the study of plasma due coronal mass ejections far from the sun and long-term variations of pulsars with the MWA, both of which are significant science goals in radio astronomy. A high-resolution source of southern mid-latitude ionospheric FR data with an uncertainty better than 0.015rad/m2 is needed to enable such polarimetric studies using the MWA.

To address this, we have been developing a new ionospheric measurement technique and 3U CubeSat beacon system. Our proposed solution is capable of delivering a direct source of southern mid-latitude ionospheric FR data with a RM uncertainty better than 0.015rad/m2. We achieve this by uniquely employing linearly polarized beacon signals, which enables us to directly measure ionospheric FR through plane of polarization measurements at a ground receiver station. Robust simulation results demonstrating our ionospheric measurement capabilities in the presence of system noise, weak scattering, clock errors and antenna characteristics will be presented. Early results from our developed beacon subsystems, including the small satellite antenna and RF transmitter, will also be shown. Further, I will also discuss that in solving this polarization calibration challenge, our solution has the potential to further aid and improve the calibration of MWA measurements for other ionospheric errors. That is, 1) improving phase calibration by providing high resolution ionospheric TEC data (with an uncertainty of ≤10mTECU), and 2) improving scintillation noise calibration by providing native ionospheric scintillation noise measurements within the MWA band. Finally, I will also discuss the future work that is essential to successfully realize this ionospheric remote sensing solution.

Shintaro Yoshiura | Ionospheric plasma bubbles in the MWA data and updates from Japan

The plasma bubble where the density of the ionosphere is low caused due to the Rayleigh–Taylor instability. As the low-density region contains a small-scale structure, the variation of total electron content (TEC) is a good indicator of a plasma bubble. The TEC data observed by the Global Navigation Satellite Systems (GNSS) shows plasma bubbles propagated to Western Australia from the equatorial region on 1st Dec 2023. The MWA coincidentally was in operation for the Epoch of Reionization science. I report the ionospheric activity found in the EoR data. The data shows that duct-like structures go through the MWA primary beam with a velocity of 100 m/s and significantly smear extragalactic radio sources. In the duct-lie structure, a source is split into multiple components and the apparent offset is larger than 1 degree.

I also report research updates from Japan such as the GPR foreground removal for detecting the 21cm signal from the Epoch of Reionization, Winsorized RFI flagging using calibrated gain amplitude, non-Gaussian-based RFI findings and drift-scan ultralow data analysis.

Rohit Sharma | Solar and Heliospheric Physics with SKA

Square Kilometre Array (SKA) will provide unprecedented quality data for solar sciences and space weather. Understanding space weather is vital for human space endeavours and territorial existence by avoiding space-based catastrophes. The Sun is a plasma laboratory capturing a variety of plasma parameters and plays a pivotal role in space weather. Thus, solar activity, including eruptions like flares, coronal mass ejection, etc., is crucial for understanding space weather.

The radio wavelengths catch various plasma systems from the solar surface to the corona from emission mechanisms like gyrosynchrotron, plasma emission, etc... These emissions are dynamic and variable in frequency and time, even during periods of low solar activity. The time-frequency and flux variability of the solar emission can span several orders of magnitude, depending on the phenomenon, magnetic topology and emission mechanism. The
These observed variabilities are due to weak energetic events requisite for nanoflare-based coronal and chromospheric heating theories.
The new-generation solar radio data like Murchison Widefield Array, LOFAR, Meerkat, EOVSA and Jansky Very Large Array supply high-sensitivity data, which provides an opportunity to probe plasma diagnostics from the solar corona and eruptive phenomena like solar flares and coronal mass ejections. The talk will summarise the latest various solar and heliophysics science cases and challenges with SKA.

Angelica Waszewski | Interplanetary Scintillation Science with the Murchison Widefield Array

Interplanetary scintillation (IPS) is the variability of compact radio sources caused by turbulence in the solar wind. IPS is a fantastic space weather tool as it is able to measure the solar wind density along any line of sight an arbitrary distance from the Sun, giving it unlimited reign to probe the entire heliosphere.
By adapting this technique for modern low-frequency instruments such as the Murchison Widefield Array (MWA) we have made some key advances. The unique capabilities of the MWA

have already been exploited to launch the IPS space weather era of the MWA, with the first detection and characterisation of a coronal mass ejection (CME), with many more potential CME candidates identified in recent data.
Owing to the huge field of view of the MWA, we are able to monitor all IPS sources across 30 degrees of the sky, leading to an unprecedented density of measurements catalogued in the largest IPS source survey to date.
In this presentation, I will give a quick overview of IPS, updates on the next data release and expansion of the MWA IPS survey, as well as how the MWA is being used to study new CME candidates in early-2023 data.

Epoch of Reionisation (EoR) Science

Cathryn Trott | Latest 21cm results from the Australian EoR team

We present the latest EoR power spectrum results from an initial set of 650 hours from the EoR0 high-band data from 2013-2023. Using the new Hyperdrive calibration software, and a set of QA metrics and thresholds developed by the Australia-based EoR team, and implemented through an efficient Nextflow pipeline, we arrive at a final integration with a subset of the cleanest data. The latest limits from z=6.5-6.8 will be presented, as well as the path forward for improving the results based on the WODEN simulation results from Jack Line.

James Chege | Lossy compression of interferometric radio-astronomical data: The impact of data compression errors on the observed power spectrum of the redshifted 21 cm signal

Current radio interferometers output multi-petabyte-scale amounts of data per year making the storage, transfer and processing of this data a sizeable challenge. This challenge is expected to persist with the next-generation telescopes such as the Square Kilometre array (SKA) which will be considerably larger in size than current instruments. Lossy compression of interferometric data post-correlation can be used to abate this challenge but any drawbacks from the compression should be well understood in advance.

Lossy data compression reduces the precision of data, introducing additional noise to the data. Since epoch of reionization (EoR) 21 cm studies impose strict precision requirements, the impact of this effect on the 21 cm signal power spectrum statistic is investigated in a bid to either understand or rule out any consequent risk of unwanted systematics.

We establish the scale of the compression noise in the power spectrum, its coherency behaviour and the finally, compare different compression parameters for optimal results. Using observed visibilities datasets as well as simulated ones, we apply visibilities compression and perform a power spectrum analysis on the reference and compressed data. We compare the power spectrum of the compression noise obtained from different compression parameters with the thermal noise and the expected 21 cm signal power.

Katherine Elder | Using beam simulations to model mutual coupling coefficients in the Phase II compact array

Measurement of the 21 cm emission of neutral hydrogen in the intergalactic medium probes the era of the first luminous objects and the era of the intergalactic medium becoming fully ionized by the first stars, the Epoch of Reionization (EoR). However, the 21 cm signal is orders of magnitude fainter than astrophysical foregrounds, as well as other sources of radio frequency interference, making it challenging to measure. It is therefore imperative that any instrumental systematic effects which could further distort spectral structure are properly understood and mitigated. Kolopanis (2023) identified a systematic in Phase II data from the

MWA which manifests as excess power. This introduces a bias that can make foregrounds couple into 21cm background modes. One possible explanation for such an effect is mutual coupling between antennas. We have built an electromagnetic software simulation of the antenna beam using FEKO to estimate the amplitude of this effect for the MWA. We have modelled multiple MWA tiles, in different orientations to study the resulting beam pattern. FEKO calculates coupling coefficients, which can be compared to an approximate model of mutual coupling accounting only for re-radiation. We find that the mutual coupling coefficient predicted by both methods is on a similar level as sensitivity of the deepest available power spectrum limits. This means that, while the mutual coupling we predict is much smaller than the systematic observed by Kolopanis et al, it is potentially brighter than forecast sensitivity limits. Further work is necessary to make more detailed predictions but the conclusion as limits are improved, mutual coupling will need to be accounted for.

Michele Bianco | From Foreground to Signal: Harnessing Deep Learning to Map Neutral Hydrogen During Reionization

The next generation radio interferometry experiments will be sensible enough not only to detect the 21-cm signal, but they will be able to map the distribution of neutral hydrogen during reionization and produce a tremendous amount of 3D tomographic data. The biggest challenge for the observational analysis of these images is to separate the 21-cm signal from the undesired foreground and instrumental noise contaminations.
Here, we present SERENEt (SEgmentation and REcovery NEtwork). A deep learning approach that works on SKA-Low mock observation with an observation time of 1000 h and in the presence of the Galactic synchrotron foreground. Our network identifies regions of neutral hydrogen (HI) and recovers the reionization 21-cm signal from those regions identified as neutral. We show that our approach can identify neutral regions during reionization with more than 87 percent accuracy and recover the 21-cm 2D power spectra with an average of 95 percent accuracy.

Cathie Zheng | A candidate field for deep imaging of the Epoch of Reionization observed with MWA

Systematics and foregrounds are the primary obstacle to measuring the Epoch of Reionization (EoR) measurement, and therefore the EoR team is focused on understanding and mitigating these effects. Kolopanis (2023) identified systematic in the Phase II data set which manifests as phase offset. It primarily appears on shorter baselines but isn't limited to them This systematic introduces an overall negative bias that can make foreground contaminated measurements appear as noise-limited constraints on the EoR signal amplitude.

One potential physical mechanism is radiative mutual coupling between tiles. To investigate, we have modelled the antenna beam using FEKO. The FEKO model is based on the model used in Sokolowski (2017). We have modeled three tiles with sixteen dipoles each. We present preliminary results of how radiative mutual coupling affects the beam pattern.

Shreyam Parth Krishna | Excision of Bright Point Source Visibilities from 21cm Data

21 cm Intensity Mapping probes the universe using the spin-flip transition of the neutral hydrogen atom. This cosmological probe has enormous potential to unravel the nature of our cosmos. Multiple next-generation radio instruments such as the Low-Frequency Array (LOFAR), the Murchison Widefield Array (MWA) and the proposed Square Kilometre Array (SKA) are either currently attempting to or hope to detect this signal. However, to detect this signal we must first remove foregrounds which are 4-5 orders of magnitude greater than the signal itself. These foregrounds are principally of two types: galactic synchrotron and extra-galactic foregrounds.

The latter in particular can be extremely bright. Such sources are already problematic within radio astronomy but can be catastrophic for the 21cm signal. Subtraction of the calibrated source in visibility space, also known as peeling, is typically done to combat this problem. However, the inherent chromaticity of various instrumental effects typically causes these bright sources to leak into and contaminate the 21 cm signal despite the peeling.

We propose the bluebild algorithm as an alternate solution. Bluebild is an interferometric imager developed to reconstruct the sky intensity matrix directly on the celestial sphere. It uses functional principal component analysis based on the intensity of sources to separate input visibilities into eigen-visibilities. These eigen-visibilities are then reconstructed into eigenimages, which can be optimally combined into energy levels for source separation. Since the PCA is done on the visibilities directly, all energy levels contain artefacts only from the sources present within themselves. This would in principle allow us to separate bright sources from the 21 cm signal

We use this principle to image a model field using bluebild. The field consists of 21 cm brightness fluctuations, synchrotron and extra-galactic foregrounds. These are in turn modulated by directed dependent and direction-independent effects. Finally, additive noise is also incorporated into this model. We use the model as an input to the Oxford SKA Radio Telescope Simulator to produce simulated visibilities and subsequently image this output using the bluebild algorithm. We then evaluate the cosmological signal extracted from the bluebild output.

Pulsars and Fast Transient (PFT) Science

Ramesh Bhat | Overview of Pulsars and Fast Transients group Activities from the MWA

Pulsars and Fast Transients (PFT) science with the MWA leverages high-time-resolution science capabilities developed around the voltage capture system (VCS) functionality, and the associated software sub-systems and processing pipelines. I will present a n overview of the current capabilities around MWAX + VCSBeam, as well as select highlights from the past accomplishments, including the recent successful completion of the data collection process for the ambitious SMART survey project, which will enable the most sensitive southern-sky pulsar survey in the SKA-Low's frequency band. With the discoveries of several new pulsars and low-frequency detections of 200+ known pulsars, SMART is already beginning to show promise. I will update on recent progress and science highlights, ongoing PFT projects, including near-future plans for a data release from the SMART. The PFT science and development with the MWA presents a range of opportunities for sub-system development, software and HPC, and spans multiple science areas including passive radar applications and cosmic ray detections. I will also remark on potential new science opportunities with the transition to Phase 3 and prospects for real-time processing of MWAX VCS data, which will facilitate the MWA e merging as a powerful low-frequency monitoring facility for pulsars and fast transient science.

Garvit Grover | The implications of quasi-periodically nulling on the pulsar death mechanism

The phenomenon of pulsar nulling, where pulsars temporarily and stochastically cease their radio emission, is thought to be indicative of a dying' pulsar, were radio emission ceases entirely. Here we report the discovery of a long-period pulsar, PSR J0452-3418, from the ongoing Southern-sky MWA Rapid Two-meter (SMART) pulsar survey. The pulsar exhibits both sub-pulse drifting and quasi-periodic nulling, the latter of which is uncommon, only reported in <1\% of the pulsar population, with even a smaller fraction showing periodic nulling and sub-pulse drifting. Our analysis shows a majority of this population has long periods and sits in the death valley', implying a connection between quasi-periodic nulling and the pulsar death mechanism. To expand this population further, we simulated long period and nulling signals and tested the efficacy of three different search algorithms, which would aid in future detections. We intend to conduct a population census on the nulling population of pulsars using MWA data. This investigation will facilitate the discernment of the prevalence of quasi-periodic nulling and the identification of any trends that could aid in the understanding of nulling and the pulsar death mechanism.

Marcin Sokolowski | High-Time Resolution GPU Imager for FRB searches at low radio frequencies

Fast Radio Bursts (FRBs) are millisecond dispersed radio pulses of predominately extra-galactic origin. Despite hundreds of FRBs discovered at frequencies above 400 MHz, only a few were discovered below 400 MHz. One of the reasons is computational complexity of low-frequency FRB searches over wide fields of view (hundreds or thousands of square degrees) and long dispersion delays (of the order of tens of seconds). I will present a recently developed imaging software BLINK utilising modern Graphical Processing Units (GPUs), which is intended to address some of these issues. The primary target instruments are the MWA and SKA-Low prototype station EDA2. BLINK imager can be compiled in either NVIDIA or AMD GPU programming frameworks on HPC or server/desktop architectures. It is intended to become a part of a GPU-based processing pipeline, which will correlate voltages recorded by a telescope (in real-time or off-line), apply calibration, form images and perform FRB and transient searches. The software will be executed entirely on GPU in order to minimise I/O operations and copying memory to and from the GPU. Hopefully, this work will enable first ever detections of low-frequency FRBs with the SKA-Low precursors in the Southern Hemisphere!

Christopher Lee | A census of millisecond pulsars with the MWA

Millisecond pulsars (MSPs) are exquisite astrophysical tools which provide unique opportunities to advance fundamental physics. The MWA is playing an important role in preparing for SKA science, having recently completed data collection for the Southern-sky MWA Rapid Two-metre (SMART) pulsar survey. With a dwell time of 4800 s and high time/frequency resolutions, SMART will be the most sensitive southern pulsar survey at frequencies below 300 MHz. Several pulsar discoveries have been made, as well as re-detections of over 200 pulsars. To date, very few southern MSPs have been observed at such low frequencies. The SMART data provide a valuable resource for studying the low-frequency characteristics of MSPs, including their spectral properties and profile evolution. Motivated by this, we are performing a census of known MSPs in the SMART data. The census will inform pulsar population simulations to assess the detectable population of MSPs in the SKA-Low band and will feed into plans for performing targeted, high-sensitivity searches for such pulsars. I will present the progress to date from these efforts, including the updated MSP census and initial results from the ongoing searches.

MWA Project Meeting

Friday, 30 August

Galactic and Extragalactic (GEG) Science

Silvia Mantovanini | Constructing a new data set for detecting Supernova remnant candidates

There is an observed discrepancy of nearly 700 sources between theory and observation for the supernova remnants (SNRs) population in the Galactic plane. Their mean radio spectral index of −0.5 makes these objects brighter at low frequencies.
The Murchison Widefield Array, a low-frequency radio interferometer, is a useful resource in detecting radio emissions from SNRs thanks to the wide field of view (10^2 −10^3 sq.deg.) and the observing band (72–300 MHz). The array has operated in two different configurations: Phase I used shorter baselines to resolve large-scale structures (2′− 15◦) reaching a noise level of 10 mJy/beam, and Phase II doubled the length of the baselines to capture the details of smaller scales (45′′ − 20′). Its lowered confusion limit enables better sensitivity over long integrations (~1 mJy/beam).
To take advantage of both the resolution and sensitivity, we are jointly deconvolving those two sets of data using a GPU-based Image Domain Gridding (IDG, van der Tol et al., 2018) extension of WSCLEAN (Offringa et al., 2014) along part of the southern Galactic plane, 285◦ < l < 70◦ and |b| < 10◦. We aim to achieve a noise level between 10–2 mJy/beam across the observing band. This work will permit us to identify several more SNR candidates and investigate the free-free absorption of the unshocked ejecta (Arias et al., 2018). In this talk, I will examine the application of the IDG algorithm in detail and show preliminary results.

Stefan Duchesne | The Galactic and Extragalactic All-sky MWA survey at 300 MHz

The Murchison Widefield Array (MWA) has over the last ten years has conducted multiple surveys - one of the most notable being the Galactic and Extragalactic All-sky MWA survey (GLEAM). GLEAM was observed at five frequencies initially, covering 72 to 231 MHz, but was also followed up by similar observations at 300 MHz. While 300 MHz MWA data have been a much more difficult calibration and imaging challenge, building on work by Cook et al. (2021) we have been able to begin processing the 300 MHz data and produce images over the sky visible to MWA. This talk will cover the progress of the GLEAM 300 MHz survey (tentatively GLEAM-300), showcasing the images and the catalogue being produced as part of this survey.

Transient Science

Lucio Mayer | Tidal Disruption Events: simulations and implications for MWA observations

I will discuss the current challenges in connecting simulations and observations of tidal disruption events, which are a novel, key multi-messenger probe of astrophysical black holes and their environments. I will then focus on the exciting prospect to use radio observations by MWA to shed new light on the physical nature of TDEs. Such observations would be complementary to others already carried out in the radio at higher
frequency bands, allowing to study in a new way the puzzling late-time emission of some TDEs.

Invited Speaker

Jordan Collier | The Australian SKA Regional Centre, the MWA, and the SKA