SPARCS IX - Pathfinders get to work

06-10 May 2019, Lisboa, Portugal

Compilation of Abstracts

Monday, 06th May

MeerKAT + MIGHTEE Status Update
Russ Taylor, Inter-University Institute for Data Intensive Astronomy

MeerKAT was officially launched in July 2018. Early Observations for the MeerKAT MIGHTEE project have begun. I will present an update on the status of the project and data processing, and progress and plans for Early Science.

ASKAP Status Update
Ray Norris, WSU/CSIRO

LOFAR Surveys
Reinout Van Weeren, Leiden University

Apertif Status Update
Carole Jackson, ASTRON

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uGMRT Status Update
Russ Taylor, Inter-University Institute for Data Intensive Astronomy

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VLASS Status Update
Lawrence Rudnick, University of Minnesota, VLASS Science Survey Group

The Very Large Array Sky Survey (VLASS) is well underway at 2-4 GHz in a unique 'on-the-fly' mapping mode. I will give a brief update on the survey design, performance, and some of the fun early results. Quick-look images are publicly available and useful for many purposes but have important limitations for quantitative science studies. I will also outline the community efforts to provide enhanced data products and some of the technical challenges still to be satisfied.

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e-Merlin Status Update

Tom Muxlow, Jodrell Bank Centre for Astrophysics

Lessons learnt from the Phase II MWA
Melanie Johnston-Hollitt, Curtin University

I will present an overview of the upgraded Murchison Widefield Array (MWA) telescope and discuss the lessons, but scientific and technical, we can drawn from the MWA as we move towards the Square Kilometre Array.

Searching and characterizing extended Galactic sources in SCORPIO
Adriano Ingallinera, INAF - Osservatorio Astrofisico di Catania

The SCORPIO project, meant to be a pathfinder for the Galactic part of the EMU survey, is giving us precise indications of which scientific discoveries and technical issues we are going to face with ASKAP, and in general with the SKA precursors. The initial survey, covering about 5 square-degrees, was conducted with ATCA in multiple configurations, with a total of 320 observing hours from 2011 to 2016. The lesson learnt is helping us to shape the data reduction and analysis of the ASKAP early-science phase, during which the SCORPIO field was observed in 2018 in band 1 and 3.

Here we present a comprehensive study of all the extended sources that we catalogued in SCORPIO using the ATCA data. The field was known to harbor 49 H II regions, 3 PNe and 3 SNRs, resolved with a resolution of 10 arcsec. Our analysis was focused on characterizing these sources and we use radio and IR data to classify previously unidentified objects. And in fact we are proposing 6 new H II regions, 2 new PNe and 3 new SNRs. Besides these, other two sources show a remarkable morphology usually associated with evolved massive stars like LBVs or Wolf-Rayet stars. Unexpectedly we were also able to study the Galactic diffuse emission, providing a detailed picture in which this emission is mainly constituted by a synchrotron and a free-free component. This has a huge implication, for example, in modeling the Galactic foreground for CMB studies.

These new discoveries further highlight the great impact that next-generation surveys are going to have on Galactic science and stellar evolution and show a possible way to optimize and exploit their scientific return.

The first SMBHs: indication from models
Stergios Amarantidis, Institute of Astrophysics and Space Sciences

We present an exploration of the expected detection of the earliest Active Galactic Nuclei (AGN) in the Universe from state-of-art galaxy formation and evolution semi-analytic models and hydrodynamical simulations. In this sense, we estimate the number and radiative characteristics of Super Massive Black Holes (SMBHs) at z >6, a redshift range that will be intensively explored by the next generation of telescopes, in particular in the radio through the Square Kilometre Array (SKA). The models/simulations suggest that SKA will detect at least 400 AGN per square degree. Additionally, we stress the importance of the volume of the simulation box as well as the initial physical conditions of the models/simulations on their effect on the luminosity functions (LFs) and the creation of the most massive SMBHs that we currently observe at the EoR.

Early Results from MIGHTEE polarization Observations
Russ Taylor, Inter-University Institute for Data Intensive Astronomy

I will present some of the early polarization results from the MeerKAT MIGHTEE project.

The POlarised GLEAM Survey (POGS): Results from the All-Sky Survey
Christopher Riseley, CSIRO Astronomy & Space Science

Investigating the origin of cosmic magnetic fields is a key science driver behind the Square Kilometre Array (SKA). With the typical sensitivity predicted for surveys with the SKA, we expect to use linearly-polarized sources to statistically probe magnetic fields in the Universe, via a grid of rotation measures (RMs).

Recent results on galaxy cluster science with the Upgraded GMRT and realtime RFI mitigation
Ruta Kale, National Centre for Radio Astrophysics, TIFR, Pune, India

The cosmic rays and magnetic fields in clusters of galaxies can be directly traced by their synchrotron emission that is detected in radio bands. We have used the Upgraded GMRT to study extended sources in galaxy clusters. The spatial and spectral resolution across remnant radio galaxies and across radio relics and halos is revealing details on unprecedented scales. Recent results from our projects will be presented. At the uGMRT we have also commissioned a realtime RFI excision system to effectively mitigate the broadband RFI mainly from power lines. The results from this novel system will also be presented.

The MeerKAT DEEP Field
Tom Mauch, South African Radio Astronomy Observatory

Using the South African Radio Astronomy Observatory's MeerKAT array we have observed a quiet southern field for ~120 hours over a period between April 2018 and January 2019. The field, called 'DEEP2', was selected to be free of bright (S>~50mJy) radio sources, and can be thought of as the radio analogue of the Hubble Deep Field. The resulting 1284 MHz image reaches a 1 sigma depth of 0.6 microJy/beam at 7.6" resolution and at its center is dominated by the effects of confusion rather than by limited dynamic range around brighter sources. I will discuss the selection of field, as well as describing the performance of MeerKAT during its early science comissioning phase in the context of editing, calibration and imaging of the DEEP2 observations.

The e-MERLIN Galaxy Evolution Survey (eMERGE) - Results fron the First Data and Image Release
Tom Muxlow, Jodrell Bank Centre for Astrophysics

The e-MERLIN Legacy programme e-MERGE is a multi-tiered consortium project exploiting the combination of very high sensitivity and spatial resolution to study the formation and evolution of star-forming galaxies and AGN out to redshifts of z~5, providing an obscuration-independent

tool for measuring massive star-formation and AGN activity across cosmic time. e-MERGE Tier 1 is concentrating on the AGN and star-formation in the μJy radio source population in GOODS-N.

I will be presenting recent science results from images and data released in the first release to the e-MERGE consortium including the characterisation of the population of >850 radio sources, and detailed studies of both a number of interesting star-forming sub-mm sources and faint AGN systems.

Magnetizing the universe with dwarf galaxies: A new low-frequency radio continuum perspective

Sarrvesh Seethapuram Sridhar, ASTRON

Magnetic fields are ubiquitous in the universe and are seen on a wide range of scales from planets all the way up to large scale cosmic filaments. However, the precise origin of these magnetic fields is unknown. Among the various models proposed in the literature, magnetized outflows from shallow potential wells in the early universe could have provided the seed magnetic fields. In this talk, I will discuss 150 MHz observations of a sample of nearby dwarf galaxies using LOFAR and how these observations allow us to probe magnetized outflows from the shallow potential wells of dwarf galaxies.

The evolution of star-forming galaxies in the faint low-frequency radio source population

Emmanuel Ocran, University of Cape Town

We study the properties of star-forming galaxies selected at 610 MHz with the GMRT in a survey covering 1.8 deg^2 down to a 10 μJy/beam rms. These were classified by combining multiple classification diagnostics: optical, X-ray, infrared and radio data. Of the 1553 SFGs from the GMRT sample, 439 have spectroscopic redshifts whereas 1094 have photometric redshifts.

We find that the IRRC of star-forming galaxies, quantified by the infrared-to-1.4 GHz radio luminosity ratio q_{IR} decreases with increasing redshift: $q_{IR} = 2.44 \pm 0.07\ (1 + z)^{-0.15 \pm 0.05}$. We use the V/V_{max} statistic to quantify the evolution of the co-moving space density of the SFG sample. Our results indicate $\langle V/V_{max} \rangle$ to be 0.53 ± 0.03, which is consistent with positive evolution.

For the 965 SFGs with r_{mag} limit of 25 and $0.002 < z < 1.5$, we construct the 610 MHz radio luminosity function. The radio luminosity function for star-forming galaxies appears to be in good agreement with previous studies. We explore the possibility of evolution SFGs radio luminosity function by separating the source into five redshift bins and comparing to theoretical models.

Optically selected quasars at low radio frequencies

Gulay Gurkan, CSIRO

I will present low-frequency radio properties of optical quasars selected from the Sloan Digital Sky Survey (SDSS) using the data from the SKA pathfinder Low Frequency Array (LOFAR) and the SKA precursor Murchison Widefield Array (MWA). These final and preliminary results show the

impact of sensitive, high angular resolution and wide spectral coverage low-frequency radio surveys which foreshadow the compelling science cases for the Square Kilometre Array (SKA).

LOFAR science: broad absorption line quasars and the path to high resolution imaging
Leahj Morabito, University of Oxford

I will present a study of the low-frequency radio properties of broad absorption line quasars (BALQSOs) from the LOFAR Two-metre Sky-Survey (LoTSS) Data Release 1. BALQSOs are thought to be either a special evolutionary link between obscured and unobscured quasars, or typical quasars viewed along a very particular line of sight. They are generally radio-quiet, but do have radio emission. After matching the LoTSS and SDSS quasar catalogues, we find that BALQSOs are more likely to be detected at 144 MHz than their non-BAL counterparts. The fraction of quasars which are BALQSOs is constant with radio luminosity at 144 MHz, which is inconsistent with previous GHz radio surveys. This implies there may be two different sources of radio emission. We find that although the radio detection fraction increases with increasing balnicity index (BI, which is linked to the BAL properties), there is no correlation between BI and either low-frequency radio power or radio-loudness. This suggests that both radio emission and BI may be linked to the same underlying process, but are spatially distinct phenomena. We confirm that BALQSOs are mostly radio-quiet at 144 MHz, with radio sizes typically less than 200 kpc. The radio sizes at 1.4 GHz tend to be even smaller than this, suggesting more extended radio emission at low frequencies. Follow-up observations with LOFAR will achieve sub-arcsecond imaging to distinguish the source of this low-frequency emission, which will help us understand how BALQSOs fit into the complete quasar picture. I will present ongoing work which addresses the challenges of high-resolution imaging at low-frequencies, and show preliminary results from a wide-field (~5 deg^2) LOFAR observation of XMM-LSS.

The promise of next-generation RC surveys: Revealing the physics and evolution of galaxies and AGN in the SKA era
Isabella Prandoni, INAF – IRA

A wealth of new data from upgraded and new radio interferometers are rapidly improving and transforming our understanding of the faint extra-galactic radio sky. Indeed the mounting statistics at sub-mJy and μJy flux levels is finally allowing us to get stringent observational constraints on the faint radio population, and on the modeling of its various components. In this talk I will provide a brief overview of the latest results, focusing on star-forming galaxies and (low power) Active Galactic Nuclei (AGN), the two populations dominating the faint extra-galactic radio sky. In particular I will highlight a) the benefit of wide-area deep samples to provide statistically robust constraints on radio source demography and evolution, and b) the added value of sub-arcsec resolution to get an unbiased census of SF, and to address the role of AGN feedback in galaxy evolution.

Tuesday, 07th May

Scientific Data Quality Assessment of MeerKAT Pipelines
Jordan Collier, Inter-University Institute for Data Intensive Astronomy (IDIA) / Western Sydney University

One of the key elements of commissioning a new instrument (and its software) is to develop a robust and comprehensive science data quality assessment, ideally in an automated fashion. For the SKA precursors, we need to quantitatively assess the science-readiness of the data products, which will also serve to develop the framework for the completely automated processes of the fully operational surveys.

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e-MERLIN pipeline and its impact on data QA
Javier Moldon, JBCA / The University of Manchester

Apertif Data QA
Betsy Adams, ASTRON

Apertif is a new phased-array for the Westerbork Synthesis Radio Telescope (WSRT), significantly increasing its field of view. Apertif will undertake a set legacy surveys, including imaging surveys that include continuum, polarization, and neutral hydrogen. I will present an overview of the data quality assessment for the Apertif imaging surveys.

MeerKATHI: A novel data reduction pipeline for MeerKAT
Kshitij Thorat, Rhodes University

The advent of SKA precursors and pathfinders, which produce large amounts of raw data, makes automated data reduction pipelines essential. Such pipelines need to be portable, shareable, given the global nature of the experiments which will be carried out with these new facilities.

In this talk, I will discuss the MeerKATHI pipeline as an example of a containerised pipeline. MeerKATHI is an MeerKATHI-data oriented pipeline which seamlessly makes use of a variety of radio data reduction, visualisation and editing software. As such MeerKATHI is an example of and template for configurable and flexible pipelines, aiding reproducibility and transparency in radio astronomy.

Of special note are the direction dependent calibration and quality assessment modules of the pipeline. The latter includes sophisticated interactive visualizations of output data products as well as automated regulation mechanisms for calibration and imaging processes in the pipeline.

ASKAP Continuum Data Processing
Andrew O'Brien, CSIRO

An overview of the data processing pipeline for ASKAP continuum data and data products from recent observations with the full ASKAP array.

QA beyond the integrated quantities
Lawrence Rundnick, University of Minnesota

I will present a framework for understanding the different types of quality assurance that we do for surveys, and then introduce a "final step" which is often missing from our discussions. That final step is how we tie the specifications or characterization of survey performance to actual science problems. I will propose a new standard for QA, viz., one that is tied to the sample size required for a given science experiment. With this language in place, I will ask all the participants at the meeting to contribute -- during the session ! -- quality requirements for specific experiments for EMU, POSSUM and VLASS.

AperCal - The Apertif Calibration Pipeline
Björn Adebahr, Astronomisches Institut der Ruhr-Universitat Bochum

The Apertif system is an upgrade for the Westerbork Synthesis Radio Telescope operating at L-Band using a Phased Array Feed (PAF). First survey operations have started in January 2019 using the system in a 40-beam configuration with 200 MHz of bandwidth.

This presentation focuses on the software design of the Apertif pipeline and explains the reasons for and possible solutions to acquire High-Dynamic-Range total power and polarisation images for the entire APERTIF survey.

ProcessMeerKAT: The IDIA data analysis pipeline
Srikrishna Sekhar, IDIA, Cape Town

We present an update on the fully automated calibration pipeline being implemented at IDIA, Cape Town. The pipeline is an end-to-end fully automated, full Stokes CASA based pipeline optimized for processing MeerKAT data. The pipeline is implemented on the IDIA cloud-based infrastructure running on hardware provided by the ILIFU national facility. It is designed to be modular, flexible and scalable. The pipeline is intended to process data from the MeerKAT LSPs and hence is designed to work for continuum, polarization, and spectral line data sets.

In order to get more reliable on and off-axis polarization behaviour, we are working with the Algorithms Research and Development (ARD) team at NRAO, Socorro on a generalized implementation of the full Stokes AW projection algorithm. This new approach to AW projection relies on modeling the aperture plane of the antenna in order to capture the details of the primary beam. We have successfully modeled the VLA, ALMA and MeerKAT primary beams using this method, and are working on a full CASA implementation.

Revolutions in polarisation: New science brought to you by ASKAP and PAFs
Craig Anderson, CSIRO

This talk will present two spectacular new science results from the Australian Square Kilometre Array Pathfinder (AKSAP), which are uniquely enabled by its innovative phased array feed (PAF) technology. I will start by presenting exquisite new wide field, broadband, full polarisation images of the outer lobes of Centaurus A, at 40x better spatial resolution than previously achieved at comparable frequencies (and 15x better than at any frequency). Our data reveal a host of new and important structures in the system, including intricate webs of depolarisation related to the internal magnetised thermal plasma structure of the lobes, signatures of strong shocks that are candidate sites for high energy particle acceleration, and large scale magnetic field structures that delineate separate physical regions of the lobes, corresponding to distinct epochs of AGN activity. I will then present the results of a "rotation measure grid" study of the Fornax cluster. We characterise its magnetic field structure through its effect on the Faraday rotation measure of background sources. This represents key science for the SKA, but has never yet been achieved for a poor galaxy cluster, and has only rarely been attempted for individual galaxy clusters of any type. Together, these results highlight the breadth of excellent science that is enabled with PAF technology, and demonstrate the importance and viability of PAFs in the SKA era.

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ngVLA Advanced Imaging and Calibration
James Condon, National Radio Astronomy Observatory

MeerKAT Imaging and DDEs
Oleg Smirnov, National Radio Astronomy Observatory

I will discuss the treatment of direction-dependent effects in MeerKAT images.

MWA Advanced Imaging and Calibration
Huib Intema, Curtin University

Wednesday, 08th May

The LoTSS optical/IR identifications
Wendy Williams, Leiden University

The LOFAR Two metre Sky Survey has a broad range of ambitious science goals. I will describe the creation of the value-added catalogue for the first data release (LoTSS-DR1), in which we have provided optical identifications and host galaxy parameters for most of the LOFAR-detected sources, in order to enable these goals. The source associations and optical and/or IR identifications were made using a combination of statistical identification and visual classification, respectively a colour- and magnitude-dependent likelihood ratio method and a Zooniverse project, called LOFAR Galaxy Zoo.

XID of the ASKAP early science cosmology field with DES using likelihood ratio
Nick Seymour, ICRAR/Curtin

An advanced Bayesian technique for radio/IR cross-identification
Ray Norris, Dongwei Fan, and Tamas Budavari, WSU/CSIRO

Cross-matching catalogues from radio surveys to catalogues of sources at other wavelengths is extremely hard, because radio sources are often extended, often consist of several spatially separated components, and often no radio component is coincident with the optical/infrared host galaxy. Traditionally, the cross-matching is done by eye, but this does not scale to the millions of radio sources expected from the next generation of radio surveys. We present an innovative automated procedure, using Bayesian hypothesis testing, that models trial radio-source morphologies with putative positions of the host galaxy. This new algorithm differs from an earlier version by allowing more complex radio source morphologies, and performing a simultaneous fit over a large field. We show that this technique performs well in an unsupervised mode.

CDFS & COSMOS field coverage with MeerKAT
Russ Taylor, Inter-University Institute for Data Intensive Astronomy

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MWA observations of all 3 fields at 150 MHz - Plus plans for cross-matching with TGSS and LOFAR/LoTSS
Nick Seymour, ICRAR/Curtin

Role of Reference Fields in HI Surveys. Latest plans for Apertif/ASKAP
Betsey Adams, ASTRON

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e-MERLIN observations of the Northern SLOAN Reference Field

Javier Moldon for Nick Wrigley, JBCA / The University of Manchester

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Thursday, 09th May

nJy Science I: Confusion is a Feature, not a Bug
James Condon, National Radio Astronomy Observatory

The 1.3 GHz DEEP2 image covers one 68 arcmin FWHM MeerKAT primary beam with 7.6 arcsec FWHM resolution and 570 nJy rms noise. Although DEEP2 is heavily confusion limited, half of its > 10,000 synthesized beam solid angles contain no sources stronger than S ~ 200 nJy. Combining its pixel brightness distribution [a.k.a. P(D) distribution] below S ~ 10 microJy/beam, its discrete source count between 10 and 2500 microJy, and the NVSS source count above 2.5 mJy yields an accurate brightness-weighted source count S^2 n(S) covering all S > 200 nJy at 1.4 GHz. Most radio sources fainter than S ~ 100 microJy are distant (<z> ~ 1) unresolved (< 1 arcsec) star-forming galaxies, so the source count enabled by the MeerKAT DEEP2 image constrains the star formation history of the universe (SFHU) all the way down to the 250 nJy detection limit of the top-priority SKA1-MID "ultra deep" SFHU reference survey.

The MeerKAT telescope is operated by the South African Radio Astronomy Observatory, which is a facility of the National Research Foundation, an agency of the Department of Science and Technology.

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nJy Science II: The Star Formation History of the Universe
Allison Matthews, University of Virginia

The radio continuum luminosity of a star-forming galaxy is a dust-unbiased indicator proportional to its star-formation rate. The local luminosity function of radio sources powered by star formation determines the mean star-formation rate density (SFRD) of the universe today. For the LCDM cosmology, each SFRD evolution function predicts a 1.4 GHz faint source count that can be compared with the S > 200 nJy count of sources in the MeerKAT DEEP2 image. The ~200 nJy sensitivity is needed to account for most of the SFHU through the z ~ 2 "cosmic noon" of normal, Milky Way-like galaxies, not just the contribution of ultraluminous galaxies. Pure luminosity evolution using the Madau & Dickinson (2014) SFRD evolution function gives a good, but not perfect, fit to the radio source count. Improved SFRD evolution functions are being explored to better fit the DEEP2 source count.

The MeerKAT telescope is operated by the South African Radio Astronomy Observatory, which is a facility of the National Research Foundation, an agency of the Department of Science and Technology.

Confusion, Correlation, and the Faint Extragalactic Radio Sky
Tessa Vernstrom, CSIRO

Advancements in radio telescopes and novel data analysis techniques now allow us to push observational limits to new depths, probing fainter galaxies and farther back in cosmic time.This talk will discuss the use of some of these new data and statistical techniques (such as confusion analysis and cross correlations) for studying point sources and source counts as well as diffuse cluster emission and the synchrotron cosmic web. I will contrast the benefits and challenges to

statistical detections for investigating the nature of the faint extragalactic components of the radio sky.

Radio luminosity functions below the detection threshold
Eliab Malefahlo, University of the Western Cape

With the lack of large area radio surveys deeper that 1~mJy at 1.4~GHz, where radio-quiet AGN and star-forming galaxies become more prominent. Using a Bayesian-stacking technique to objects below the nominal flux limit we present the radio luminosity function of i) optically-selected quasars below 1 mJy to investigate the source of radio emission in radio-quiet quasars and ii) near-Ultraviolet selected star-forming galaxies to probe the cosmic star-formation history.

Polarization and spectral index of mJy radio sources as a function of source structure from stacking
Joroen Stil, University of Calgary

The faint polarized intensity of extragalactic radio sources is a natural target for stacking considering the complete target list comes from an unconfused survey in total intensity. The challenge with stacking polarized intensity is the non-linear relation between the true signal and the stacked (median) signal of the sample. I present results from stacking polarized intensity of extragalactic sources between 10 mJy and 100 mJy in relation to source structure and find that the median polarization of radio galaxies is strongly related to structure.

Source Finding in Crowded Fields
William Cotton, NRAO

The process of deriving a catalog of sources from images of crowded fields, even if most are unresolved, presents a number of challenges.

Peaks in the images are frequently blends of sources and the "noise" in the image may be seriously non Gaussian. This talk discusses cataloging of sources in a strongly confusion limited field of extragalactic sources observed with the MeerKAT array at 1.2 GHz. In this context, source finding consists of defining islands and regions of emission, identifying peaks and fitting a set of elliptical Gaussians. Several constraints are needed to guide the fitting towards a more plausible set of sources. A simulation of this field is used to evaluate the reliability of the resultant source list and allows determining the depth to which identifying real sources is reliable.

Results from the Stripe 82 XID
Matt Prescott, UWC

I will present results from a cross-match between a 1-2 GHz radio survey conducted with the JVLA and optical data from the SDSS. Here I will show the properties of different radio source

populations vary and have evolved from z = 1.0. The lessons learned from this study will be helpful for the upcoming MIGHTEE survey.

The GAMA Legacy ATCA Southern Survey (GLASS)
Minh Huynh, CSIRO

The GAMA Legacy ATCA Southern Survey (GLASS) is an ATCA Legacy survey which will cover the full GAMA G23 field with up to 3000 hours on ATCA over six semesters. The full 50 square degrees will be imaged at two 4cm bands, reaching ~30 and ~50 microJy rms sensitivity at 5.5 and 9.5 GHz, respectively. With this unique dataset we will: 1) study the properties and evolution of AGN, and 2) calibrate and investigate non-thermal and thermal radio star formation rate measures in normal galaxies.

The G23 region is set to be one of the foremost legacy regions in the southern sky. Existing data include deep UV-FIR imaging, 60,000 optical spectra, and full value-added properties such as group catalogues, SFRs, stellar masses, dust masses, metallicities, photometric redshifts and full SED fits. The future Wide Area VISTA Extragalactic Survey (WAVES) will also target the GAMA G23 region, going to fainter magnitudes than GAMA.

This will be the deepest wide survey at high radio frequencies until the SKA comes online.

I will discuss the status of this ATCA Legacy survey and present the initial results from this project.

MWA Interestingly Deep AStrophysical (MIDAS) survey
Nick Seymour, ICRAR/Curtin

I will present the latest update on surveys with the Murchison Widefield Array (MWA) with a particular focus on the deep surveys. In phase 2 of the MWA will maintain its fast survey speed, high sensitivity to low surface brightness and its wide frequency coverage. The MWA Interestingly Deep AStrophysical (MIDAS) survey is targgeting the five GAMA survey fields and the SPT deep field, providing photometry acress 70 to 230 MHz. The aim is to achieve 0.5 mJy/beam RMS at the highest frequency. I will highlight some of the science to date exploiting the broad band radio spectral energy distributions. I will also provide an update on MWA observations of the SPARCS reference fields..

Radio Galaxy Classification - the next generation
Lawrence Rudnick, University of Minnesota

With the next generation of radio surveys well underway, the advent of Citizen Science, and the rapid advances in Machine Learning, it is time to revisit our decades old schemes for radio galaxy classification. This needs to be motivated by our wide range of science goals, and moderated by the limitations of surveys and analysis technology. I will summarize discussions that have taken place within the EMU project and plan to then facilitate an open-ended discussion on these issues.

Unsupervised Clustering of Convolutionally Encoded Radio-astronomical Images
Nic Ralph, Western Sydney University

The rapidly increasing volume of radio-astronomical data has increased demand for machine learning methods as solutions to classification and outlier detection. Major astronomical discoveries are unplanned and found in the unexpected, making unsupervised machine learning highly desirable by operating without assumptions and labelled training data. Our approach shows SOM training time is drastically reduced and high-level features can be clustered by training on auto-encoded feature vectors instead of raw images. Our results demonstrate this method is capable of accurately locating separating outliers on a SOM with neighborhood similarity and K-means clustering of radio-astronomical features complexity. We present show this method as a powerful new approach to data exploration by providing a detailed understanding of the morphology and relationships of Radio Galaxy Zoo (RGZ) dataset image features which can be applied to new radio survey data.

Dimensionality reduction techniques for interferometric imaging
Landman Bester, South African Radio Astronomy Observatory

Robust image reconstruction techniques are required to maximize the scientific potential of radio interferometric data. Unfortunately, most such techniques require thousands of iterations through the data and therefore struggle to keep up with the onslaught of data expected from current and upcoming surveys. In this talk, I will demonstrate how we can borrow ideas from the infamous CLEAN algorithm to speed up more sophisticated deconvolution algorithms.

Using Deep Learning to Detect Complex Faraday Rotation Measures
Shea Brown, University of Lowa

We present a deep convolutional neural network that can automatically classify complex Faraday rotating sources in upcoming radio surveys. In this presentation we will outline the construction and testing of the network, and highlight ways in which deep learning in general can solve astrophysical model selection problems where classical Bayesian techniques are too computationally demanding.

Extended radio luminosity functions with Radio Galaxy Zoo and machine learning
Matthew Alger, Australian National University

Studying extended radio sources en masse is challenging, as it is difficult to quickly and reliably determine their host galaxies. We train a machine learning model on cross-identifications from the Radio Galaxy Zoo citizen science project. Using this model, we cross-identify 214~214 radio components from the Faint Images of the Radio Sky at Twenty-centimeters survey (FIRST) with 157~007 mid-infrared host galaxies from the AllWISE source catalogue; 17 per cent of these hosts have a spectroscopic redshift in the Sloan Digital Sky Survey (SDSS). This is the largest sample of cross-identified extended objects to date. The large sample size allows us to estimate luminosity functions of extended radio sources, split by mid-infrared colour, physical extent and redshift.

Classification of simple and complex sources and optimum techniques for rotational invariance

Ray Norris & Lawrence Park, WSU/CSIRO

Next-generation radio continuum surveys will generate images of millions of radio sources, which will require automatic classification and cross-identification against multi-wavelength images. About 90% of these sources will be simple single compact objects, whilst the remaining 10% will have a complex structure consisting of several components. A numb er of approaches are being explored to classify and cross-identify the complex sources, but it is wasteful of resources to use these sophisticated approaches to classify and cross-identify the simple sources, so the first step of classification is to distinguish between the simple and complex sources. Here we examine five machine-learning approaches and the effect of preprocessing on the problem of deciding whether sources are simple or complex. We also explore whether the tradition approach of making multiple rotated copies of training set images is the optimum approach to achieve rotational invariance.

Identifying and collating related radio components in the sky within a (semi)-unsupervised framework using PINK

Tim Galvin, CSIRO

The radio sky to be reveal by the next generation of radio telescopes will contain millions of sources. Current methods of classifying the nature of detected radio sources and identifying related components (e.g. resolved lobes of AGN) rely heavily on manual inspection and will not scale. We investigate how PINK, an unsupervised machine learning method, may be used to growing problem. By constructing a manifold of representative prototypes, we project the problem to a simpler space that allows for manually inspection and object annotation. This manifold can then be used as a mechanism to transfer generalized knowledge onto specific objects. We present the approach and initial results from using a combination of FIRST and WISE data.

Friday, 10th May

Redshift Determination
Ray Norris & Kieran Luken, WSU/CSIRO

All-sky radio surveys such as EMU will produce catalogues of tens of millions of sources with limited multi-wavelength photometry. Spectroscopic redshifts will only be possible for a small fraction of these new-found sources. We present the results of a comparative study of a number of different machine-learning algorithms for obtaining redshifts with photometric data of limited quality. We also explore the use of k-Nearest Neighbours (kNN) Regression and Random Forest classification for the estimation of redshift of these sources, and are able to estimate redshifts for about 90% of sources with adequate photometry, and show that the relatively simple kNN regression algorithm is an good method of estimating redshift. However, we are still limited by the paucity of high-redshift sources in our training sets.