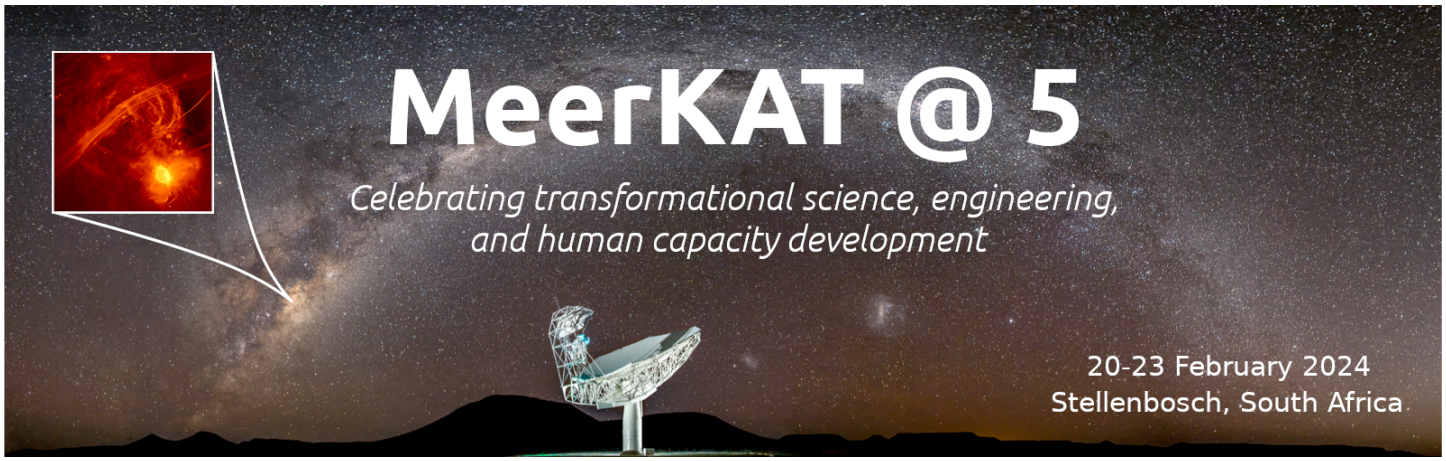

Conference Abstracts

Contents

Contributed Talks – Long

Relativistic jets in our galaxy

Rob Fender
University of Oxford, University of Cape Town

Jets from stellar-mass black holes and neutron stars in X-ray binary systems are the most relativistic flows in our galaxy, are possible sites for high energy cosmic ray and neutrino production, energise and distort the interstellar medium and allow us to understand the life cycles of jets from supermassive black holes on humanly accessible timescales. In this talk I shall summarise the state of the art of the field, and discuss how five years of observations of these phenomena, as part of the ThunderKAT Large Survey Programme, have transformed our understanding of the life cycles of these jets. The results include 1. The first large completely homogeneous sample of radio and X-ray luminosities of these sources, providing the most precise test of the coupling between steady-state jets and the associated accretion flow, 2. Four+ new examples of large-scale, decelerating jets, transforming our understanding of the kinetic energy of these jets and how they deposit that energy in the interstellar medium, 3. A spectacular view of a jet from a neutron star binary punching a hole in the shell of its natal supernova, providing strong constraints on the power in a neutron star jet, and much more. I shall furthermore discuss how future observations with improved multiwavelength coverage, and taking advantage of MeerKAT's evolution towards SKA-MID, can continue to push the boundaries of the field.

The MeerKAT Pulsar Timing Array

Ryan Shannon
Swinburne University of Technology

Opening a new, nanohertz-frequency, window to the gravitational-wave Universe is possible through the timing of an array of millisecond pulsars. The gravitational wave sky in the band is expected to be dominated by a stochastic background produced by binary supermassive black holes. In order to detect background, the presence of "Hellings-Downs" angular correlations between the pulsars in an array is required. Pulsar timing array experiments in Australia, North America, and Europe have recently observed modest (3-sigma) evidence for these spatial correlations. In order to make a significant detection it is necessary to observe pulsars over a longer

timing baseline, monitor a larger ensemble of pulsars, time pulsars to higher precision, or all. We introduce the MeerKAT Pulsar Timing Array. This array monitors a large number of pulsars (90), to high precision, and at the highest cadence of any extant pulsar timing array. We assess the sensitivity of the array. We present the results of the first searches for temporal and correlated signals. We compare the results to those from other timing array experiments and discuss the implications models for supermassive black hole populations. We conclude by motivating the science possible with a SKA pulsar timing array and motivate searches as part of the International Pulsar Timing Array.

The MeerKAT Fornax Survey: removal of HI from galaxies in the Fornax cluster

Paolo Serra

INAF - Osservatorio Astronomico di Cagliari

I will show science results from the MeerKAT Fornax Survey. Our goal is to perform a detailed study of the nearby Fornax galaxy cluster in order to understand how galaxies lose their cold gas and stop forming stars in low-mass clusters (Mvir $<$ 1e+14 Msun). We are doing so through very deep (down to $\sim$1e+18/cm^2) and high resolution (up to $\sim$ 1kpc and 1 km/s) MeerKAT observations of HI gas in a 1x2 Mpc^2 region centred on Fornax.

Our survey started in October 2020 and is now 70% complete. These first data focus on the central region of the Fornax cluster and reveal for the first time the ubiquitous presence of tails and clouds of HI. Some of the HI is clearly being removed from Fornax galaxies as they interact with one another, with the intra-cluster medium and/or with the large-scale gravitational potential. I will present a sample of galaxies with long, one-sided, star-less HI tails (of which only one was previously known) radially oriented within the cluster and with measurable internal velocity gradients. The properties of these tails represent the first unambiguous evidence of ram pressure shaping the distribution of HI in the Fornax cluster. I will also discuss additional results on how interactions within the Fornax environment shape the HI mass function and the HI content of dwarf galaxies.

MIGHTEE: Past, present and future

Matt Jarvis

University of Oxford

I will give an overview of the MIGHTEE survey, highlighting science that has been achieved and the lessons learnt from conducting an ambitious survey that covers, spectral line, polarisation and continuum science. I will then focus on how we can take what we have learned, both scientifically, technically and in terms of organisation in order to maximise the science from the SKA.

Simulating the MeerKAT Universe

Romeel Dave
University of Edinburgh

MeerKAT surveys of the extragalactic universe are revolutionising our view of galaxy evolution in the radio. Galaxy formation simulations are vital for contextualising and interpreting the results within the modern multi-wavelength landscape, in order to provide constraints on the most uncertain aspects of galaxy evolution such as feedback and black hole growth. I will describe how we are using our group's novel Simba simulation suite to explore galaxy evolution in the radio as seen with LADUMA, MIGHTEE, and other extragalactic surveys. The combination of simulations with MeerKAT data has already yielded many new insights, as well as predictions that will be tested with upcoming programs.

A mob of MeerKAT FRBs and Galactic transients found with MeerTRAP

Ben Stappers
University of Manchester

MeerTRAP is a commensal project which searches for Fast Radio Bursts (FRBs) and Galactic transients while piggybacking on MeerKAT observations. The exceptional sensitivity of MeerKAT combined with the power of the user supplied equipment (FBFUSE and TUSE) to form hundreds of coherent beams and search them in real time is revealing interesting populations of both extragalactic FRBs and radio emitting neutron stars in our own galaxy. This talk will present the MeerTRAP project and describe results of both searches. It will present the population of more than 45 FRBs found to date and compare them to the known population. It will show how the combination of searches with a wide field through the incoherent beam (probing the higher luminosity regime) and coherent beams represents two separate samples of he population. The multi-frequency capabilities of MeerKAT mean MeerTRAP is also probing the frequency dependence of FRBs and we will report the first FRB ever discovered in S-band. MeerTRAP has also discovered almost 100 new Galactic sources and we will present the nature of this population which is revealing a long-period population. With repeat visits to many of the fields we have been able to measure periods and period derivatives and so are able to show how these sources are extending and filling in gaps in the period-period derivative graph. This has important implications for the spin and emission evolution of radio emitting neutron stars.

The MHONGOOSE Nearby Galaxies Large Survey Project

Erwin de Blok
ASTRON/UCT/Kapteun

The MHONGOOSE Large Survey Project uses MeerKAT to map the distribution and kinematics of the neutral hydrogen (HI) gas in and around 30 nearby star-forming spiral and dwarf galaxies to extremely low column densities in order to detect cold gas accretion. This process is predicted by numerical simulations to be replenishing the gas consumed by star formation, thus enabling the galaxy to continue forming stars throughout cosmic time. The survey is now over 75% complete, and is reaching its target HI column density sensitivity of a few times 10^{17} atoms cm^{-2}, close to two orders of magnitude lower than the column densities typically found in galaxy HI disks. Our full-depth data show that the outskirts of the galaxies are complex and dynamic environments, with many potential accretion and interaction features that become only now visible at these low column densities. We also detect a significant number of hitherto uncatalogued low-mass dwarf galaxies, which enable us to expand science that was so far only possible in the Local Group to other environments at tens of Mpc distance. A first comparison of the MHONGOOSE galaxies with simulated HI data extracted from recent cosmological numerical simulations shows little evidence for the extended "cold accretion" gas filaments that these simulations predict. This discrepancy between observations and simulations is a challenge but also points the way forward to a better understanding of the role of gas accretion in galaxy evolution.

Finding pulsars with MeerKAT: The TRAPUM Program

Ewan Barr
MPIfR

In its fourth year, the TRAPUM (Transients and Pulsars with MeerKAT) project continues to deliver a wealth of discoveries. Focusing on globular clusters, nearby galaxies, and high-energy sources lacking radio associations, this wide-ranging survey has identified more than 130 new pulsars, primarily consisting of fast-rotating millisecond pulsars (MSPs) formed through companion star mass transfer. The findings encompass intriguing binary systems, including "spider" systems with an MSP orbiting a low-mass non-degenerate companion, 13 new pulsars from Magellanic clouds, and a potential neutron star-black hole binary within the NGC 1851 globular cluster—a rare discovery within the LIGO "mass gap." Essential to these outcomes is was the development of a specialized multibeam beamformer, capable of greatly expanding MeerKAT's high time-resolution survey capabilities. This technology, coupled with a 60-node GPU cluster for data processing, underpins both TRAPUM and Max-Planck-Institut für Radioastronomie (MPIfR) MeerKAT Galactic Plane survey (MMGPS) initiatives, enabling groundbreaking quasi-real-time pulsar searches. These searches, akin to the SKA's proposed approach, offer

crucial insights into wide-field interferometric pulsar surveys. This presentation outlines TRAPUM's instrumentation, recent scientific outcomes, and insights gleaned from three years of operational experience.

Cosmology with MeerKAT: the MeerKLASS project

Mario Santos
UWC

MeerKAT's exquisite sensitivity and instrumental stability has made it an excellent medium to test cosmology. This is particularly true using the neutral hydrogen intensity mapping technique which allows MeerKAT to measure the HI distribution across the universe up to $z \sim 1$ over wide areas. I will introduce MeerKLASS, a large project aimed at probing cosmology using MeerKAT single dish data, as well as producing high resolution interferometric images over vast regions of the sky. I will describe the pipelines developed and the results that have been achieved so far, including the first detections of the HI power spectrum using this technique. I will end with a discussion of the plan for the next five years, which aims to measure with high accuracy several key metrics for cosmology, such as baryon acoustic oscillations, redshift space distortions and the shape of the power spectrum on ultra large scales.

The MeerKAT Absorption Line Survey (MALS): Overview and results

Neeraj Gupta
IUCAA, India

The MeerKAT Absorption Line Survey (MALS; https://mals.iucaa.in/) consists of 1655 hrs (1.5 PB raw visibilities) of MeerKAT L (900-1670MHz) and UHF (580-1015MHz) band time to carry out the most sensitive blind HI 21-cm and OH 18-cm absorption line survey. The L-band phase of the survey is completed and the observations with UHF-band are in progress. Through these we have recently reported: (i) the detection of the most luminous known 1720 MHz OH maser line, (ii) the discovery of the first extragalactic Hydrogen radio recombination line at cosmological distances, and (iii) the variability of the HI and OH 21-cm lines at $z = 0.247$ and 1.173. The first MALS data release (DR1) based on 495,325 (240,313) sources from narrow-band ($\sim$60 MHz) images at 1006 MHz (1381 MHz) is now public (2023 Q3). This is the first of several data releases to come from MALS. In this talk, I will present (i) an overview of the survey, (ii) key results, with focus on occurrence of cold atomic and molecular gas in and around the Milky Way and external galaxies ($0 < z < 0.5$), and (iii) technical challenges and the data release plan.

Contributed Talks – Short

Discovering radio transients with machine learning and citizen science

Alex Andersson
University of Oxford

Current and upcoming interferometers can now sample wide swathes of the radio sky with unprecedented sensitivity and cadence. As a result, we can now discover radio transients across an immense range of astrophysical regimes − from flare stars to FRBs. I will discuss recent, serendipitous discoveries being made with the MeerKAT radio telescope and how we can make the most of new facilities coming online. This includes how citizen scientists have scoured through commensal data and uncovered 100s of new variable sources. This is the first ever crowdsourcing project dedicated to radio transients in this manner and has uncovered variable sources as different as nearby flare stars, pulsars and AGN. Furthermore, I will discuss the efforts taken to engage communities around South and southern Africa with this work, including a workshop run with young learners from the Northern Cape. Finally I will detail novel machine learning techniques being developed to speed up the search for interesting and anomalous sources, methods that will prove invaluable as we look towards observatories such as the SKA and the data rates that accompany them.

Developing engaging outreach programs using the MeerTime Large Survey Project

Matthew Bailes
Swinburne University of Technology

The MeerKAT is an amazing pulsar telescope, offering exquisite data on the wealth of pulsars accessible from the Southern sky. In this talk I will discuss how students can learn about pulsars using a new powerpoint-like tool developed by OzGrav known as OzVU, and take pulsar data from the MeerKAT telescope to learn about the speed of light, the orbit of the Earth around the Sun, and the scales of relativistic binary pulsars and the relativistic phenomena they exhibit. These lessons teach the children about how physical theories can be tested with hands-on science practicals and help debunk growing ignorance and skepticism about science and its predictions.

Recent results from LADUMA

Sarah Blyth
University of Cape Town

The Looking At the Distant Universe with the MeerKAT Array (LADUMA) survey is a MeerKAT Large Survey Project whose primary aim is to study the evolution of neutral atomic hydrogen (HI) in galaxies over the past 9 billion years of cosmic history. This effort will enable new insights into the gas content of galaxies and the processes involved in galaxy evolution beyond the local Universe. I will present an overview of recent science results from the LADUMA survey, focusing on those obtained from our initial L-band dataset, which will be the subject of a public release in the near future.

Surface brightness edges in radio halos

Andrea Botteon
INAF-IRA

Radio halos are diffuse synchrotron sources that permeate the volume of merging galaxy clusters. Historically, they have been described as "smooth" sources with "regular" morphology. In my talk, I will discuss how this definition of radio halos is not valid anymore, especially thanks to recent MeerKAT observations. In particular, I will report on the detection of radio surface brightness discontinuities in the radio halos from the MeerKAT Galaxy Cluster Legacy Survey which resemble (and sometimes coincide with) the X-ray surface brightness discontinuities due to shocks and cold fronts in the intra-cluster medium (ICM). This indicates that radio halos are actually rich in substructure and that their morphology is shaped by dynamical motions in the ICM during cluster mergers. I will thus discuss the implications and prospects of these results.

Physics of the oldest phases of AGN bubbles in a galaxy group

Marisa Brienza
OAS-INAF/University of Bologna

Jetted Active Galactic Nuclei (AGN) recurrently inflate lobes of relativistic plasma and magnetic fields, which are thought to rise buoyantly as light bubbles into the intragroup/intracluster medium, counterbalancing its spontaneous cooling. Understanding how these bubbles evolve and eventually mix with the surrounding gas on long timescales is important to constrain the impact they have on the thermal and non-thermal history of the system. Observing this phenomenon has always posed challenges but, thanks to the SKA precursors/pathfinders, significant progress has been made in recent years. With four distinct generations of radio lobes, the galaxy

MCG+05-10-007, at the center of the group Nest200047, represents one of the clearest pieces of evidence of the recurrent nature of AGN jets and, for the first time, has shown us how the AGN jet-inflated bubbles can get shredded into intricate filamentary structures over hundreds of million years, whose physics is still a mystery. Here I present a broad-band resolved spectro-polarimetric analysis of this system, performed by combining UHF and L-band MeerKAT observations with LOFAR, uGMRT, and VLA data in the range 53 to 1500 MHz. By employing of techniques such as spectral index maps, color-color plots, shift-plots and Faraday Rotation, we obtain new insights into the physics of the system AGN duty-cycle, the nature of the filaments, and the role of magnetic fields in the plasma evolution. The study clearly shows the power of the combined use of high-quality, new-generation radio data.

Listening to the Slow Symphony: Investigating the Secrets of Long Period Radio Transients

Manisha Caleb

University of Sydney

The quest for transients has evolved into a thriving field with the emergence of wide field-of-view SKA precursors like MeerKAT and ASKAP. In recent years, we've seen the emergence of a new class of "ultra-slow" radio transients with previously unanticipated spin periods. These peculiar objects inhabit the neutron graveyard where they are not expected to be detectable under the currently understood framework of coherent radio emission. Think zombie stars! The 76-second period source discovered with the MeerKAT telescope exhibits short-timescale strongly quasi-periodic structure, which could be interpreted as seismic vibrations or crustal oscillations of the neutron star. The more elusive 54-minute period source discovered with ASKAP, and followed-up and detected with MeerKAT, is one of the longest-period coherent emitters known to date and is extremely intermittent. Intriguingly, neither of these sources have multi-wavelength counterparts, thereby making their nature hard to discern. These findings imply that we have merely scratched the surface, and numerous other similar objects might be waiting to be uncovered. We need only look! In my talk I will present the recent ultra-long period source discoveries from SKA pathfinder radio telescopes and discuss the possible relation of these objects to the mysterious fast radio bursts given the similarities in pulse morphologies and polarization properties.

High Latitude Supernova Remnants at 1.3 GHz

William Cotton, F. Camilo, R. Kothes, P. Chandra
(US) National Radio Astronomy Observatory

We present the results of full Stokes MeerKAT observations of 36 supernova remnants with $|b| > 1.5$ deg. with a typical resolution of 7.5″ and an RMS of 30 microJy/bm in Stokes I. While some of these remnants are well known, we present radio images of significantly better quality than many of those previously available in the literature allowing much improved characterization of the remnants. Since the remnants reported on are at relatively high latitude they are mostly isolated and not overlapping other remnants or HII regions. We determined that G30.7-2.0 is not, in fact a SNR, but 3 background source in an arc. Special attention is paid to the polarimetry which reveals the magnetic field structure in and magnetized plasma around the remnants. SNR G327.6+14.6 (SN 1006) offers an unusual opportunity for testing for Faraday rotation and depolarization interior to the remnant with an extended AGN partially behind it.

Breakthrough Listen's Automated Commensal Technosignature Search with MeerKAT

Daniel Czech
UC Berkeley

Breakthrough Listen's User Supplied Equipment (BLUSE) is a powerful system built to search for evidence of extraterrestrial intelligence with MeerKAT. It operates an entirely automated commensal technosignature survey alongside MeerKAT primary observations, analysing targets of interest that fall within the primary field of view.

Until recently, most radio technosignature surveys have been conducted with large single-dish radio telescopes. However, arrays like MeerKAT offer (among other benefits) a much larger primary field of view without compromising on sensitivity. In addition, MeerKAT's pioneering Ethernet-based architecture is well suited for automated commensal observing.

As an entirely commensal system, BLUSE takes advantage of these features to analyse targets of interest that fall within the field of view during primary observations. Data are received directly from the F-engines, and are upchannelised to produce spectra with channel bandwidths of approximately 1 Hz. Synthesized beams are formed on targets of interest and a narrowband technosignature search is conducted on the resultant output. To ensure an abundance of targets, an all-sky Gaia-derived catalogue of approximately 32 million nearby stars has been compiled.

We discuss BLUSE's innovative architecture and describe its automated operation and capabilities, in terms of both hardware and software. We present scientific results from the ongoing technosignature survey. Finally, we discuss current work and future enhancements to the system and technosignature search pipeline.

One of Breakthrough Listen's principal goals is to survey more than 1 million nearby stars and other objects individually for evidence of extraterrestrial intelligence. MeerKAT's unparalleled advantages for rapid commensal observing render this an attainable goal, soon to be achieved.

Imaging science with the MPIfR MeerKAT Galactic Plane Survey (MMGPS)

Ancor Damas Segovia

Max Planck Institute für Radioastronomie (Bonn)

The MPIfR MeerKAT Galactic Plane Survey is a 3000-hour full polarization survey that covers 900 and 300 square degrees at L, S, and UHF band, respectively. This is the first SKA pathfinder survey where both continuum/imaging and time-domain surveys are observed commensally. This survey will have the broadest frequency coverage of the southern sky among the SKA pathfinder surveys. It will also produce a broadband Faraday rotation measure (RM) catalogue of extragalactic sources at a density of 25 deg^{-2}. The use of this RM grid and Faraday tomography of the diffuse radio emission will give us access to study the small and large scale magnetic fields of the Milky Way and background polarized sources with a quality never seen before. The Pipeline used to calibrate and image the MMGPS full Stokes data has been developed at the MPIfR − the current state of the software can perform a full stokes calibration, multi scale imaging, polarization cubes, and self calibration of L and S band data from MeerKAT. Currently, the L band part of the survey is completely observed and final images show $7''$ resolution images with an rms noise of 16 µJy/beam at L band. The S band observations of the Galactic plane already began in collaboration with the South African Radio Astronomical Observatory (SARAO) with outstanding preliminary results. In this talk, we will present the first results of both L and S band surveys.

Strong Gravitational Lensing with MeerKAT

Roger Deane

University of the Witwatersrand / University of Pretoria

Our view of the cosmic evolution of neutral hydrogen and the hydroxyl molecule in galaxies is being transformed through deep surveys with SKA precursors/pathfinders. Strong gravitational lensing can enable a deeper tier to the ongoing and planned spectral line surveys, without some of the associated calibration risks posed by several thousand-hour integrations; source confusion; image-plane cube combination; and enormous data volumes. In this talk, I will present how relatively modest programmes on MeerKAT targeting known, OIR-identified strong lensing systems are delivering amongst the most distant views of HI and OH emission in galaxies over cosmic time, providing a highly complementary approach to high-redshift spectral-line surveys on MeerKAT, and other facilities. Indeed, strong lensing surveys have leveraged this utility for decades in virtually every part of the electromagnetic spectrum, including almost every major spectral line that traces the interstellar medium in galaxies. MeerKAT's exquisite sensitivity is demonstrating that we are now able to exploit the power of lensing to explore the high-redshift HI and OH universe.

Cosmic beasts and where to find them: Revealing hidden giant radio galaxies with MeerKAT

Jacinta Delhaize
Unniversity of Cape Town

Giant radio galaxies (GRGs) are truly the biggest beasts among the galaxy menagerie. With end-to-end radio jet sizes of greater than 700 kpc, they often span wide angles on the sky and are thought to be the grand elders of the radio galaxy population. And yet, they have been strangely elusive since their initial discovery in the 1970s and little is known about their true natures. Until now. The sublime surface brightness sensitivity of MeerKAT is revealing new populations of GRGs which had hitherto been hiding in plain sight! The highly extended and diffuse nature of their emission meant that many of these monsters went undetected in pre-SKA precursor era sky surveys. I will present several new GRGs unveiled with MeerKAT via the MIGHTEE survey (Delhaize et al., 2021; Netshiavha et al., in prep), and discuss the subsequent characterisation of their physical properties via follow-up UHF observations and spectral index studies (Charlton et al., in prep). These observations have unlocked a new part of parameter space with which we can study the impact of active supermassive black holes on the evolutionary pathways of galaxies.

A study of the exotic pulsars in the globular cluster NGC 1851

Arunima Dutta
Max Planck Institute for Radio Astronomy, Bonn, Germany

The exceptionally high stellar densities in the cores of globular clusters (GCs) makes them remarkable hosts for an exotic binary pulsar population. In this talk, I will discuss a pair of massive binary pulsars in the dense globular cluster NGC 1851, observed with the MeerKAT as a part of the TRAPUM (TRAnsients and PUlsars with MeerKAT) GC Survey. Both systems consist of millisecond pulsars in eccentric orbits with massive companions, suggesting that they are the likely products of secondary exchange encounters. The first one is the second most eccentric binary pulsar in a GC and the mass of the companion suggests that it is a very massive carbon-oxygen white dwarf. The total mass of the second binary exceeds the heaviest double neutron star known in our Galaxy. It is also heavier than the most massive NS-NS merger candidate in LIGO/Virgo data. The derived companion mass places it as a compact object mass-gap candidate, with a mass larger than the largest precisely measured pulsars and smaller than the lightest known stellar-mass black holes (BHs). If the companion is identified as a massive neutron star, it would provide valuable insights into the equation of state of dense nuclear matter, leading to new constraints. On the other hand, if it is identified as a black hole, it would signify the discovery of the first millisecond pulsar-BH system. This would offer a unique opportunity to test the properties and formation mechanisms of black holes.

MeerKAT HI observations of nearby spiral galaxies: the physical driver of R_{mol}

Cosima Eibensteiner
NRAO, Charlottesville

Understanding the molecular gas fraction is of crucial relevance to the evolution of the interstellar medium (ISM) for star formation in galaxies. Mass flows from the outermost regions (atomic gas) supply the centers of galaxy (where it gets converted to molecular gas) with fresh material for star formation. In my talk, I show where the atomic gas becomes molecular (surface density of atomic gas $\sim$ surface density of molecular gas) in nearby galaxies using new high-quality observations from MeerKAT and ALMA, for HI and CO, respectively, and how this transition depends on global galaxy properties.

We define the transition from atomic to molecular dominated phase similar to other studies as $R_{mol} = \Sigma_{mol}/\Sigma_{atom} = 1$ and measure how R_{mol} depends on local conditions in the galaxy disks supported by multi-wavelength observations (from MUSE, GALEX, SPITZER, and WISE). For this we use a compiled dataset containing new observations from the MeerKAT telescope targeting the galaxies NGC 1512, NGC 4535, and, NGC 7496, from the first results of the PHANGS-MeerKAT survey (from cycle0: PI: D. Utomo, and in the future including 10 more galaxies from cylce1: PI: D.J. Pisano) and together with the galaxies IC1954, NGC 1566, NGC 1672, NGC 3511, and NGC 5068 from the MHONGOOSE survey (deBlok+2016) form a sample of eight nearby (D = 5.2 - 19.4 Mpc) spiral galaxies that have the required multi-wavelength observations available. With upcoming high-sensitive and high-resolution observations with MeerKAT, the analysis I present forms a first step towards the investigation of how global galaxy properties (stellar mass, star formation rate, or morphology) impact the conversion from atomic to molecular gas in nearby galaxies (D $<$ 20 Mpc or $z < 0.005$).

On the masses of heavy white dwarf companions of pulsars

Paulo Freire
Max-Planck-Institut für Radioastronomie

In this talk, I will highlight some of the recent MeerTIME results, in particular mass measurements for mildly recycled pulsars with massive white dwarf (WD) companions. Over the last few years, these measurements have shown, surprisingly, that the masses of heavy WDs occur in relatively narrow, discrete ranges, with the WD mass distribution showing strong multimodality. The main group has companion masses between 0.8 and 0.94 solar masses, the second group has companion masses of $\sim$1.3 solar masses. In this talk I will discuss some of the specific mass measurements − including new MeerKAT results − that have been reinforcing this emerging trend. Secondly, I discuss the differing orbital characteristics of each group, showing in particular that the systems with 1.3 solar mass companions have a narrow range of orbital and spin periods. I conclude by discussing hypotheses for the origin of this

mass multimodality.

Where do neutron stars get their mass from? And how did the MeerKAT get its stripes?

Marisa Geyer
University of Cape Town

Where do neutron stars get their mass from?

And how did the MeerKAT get its stripes? Observing intriguing phenomena, such as large ranges in neutron star (NS) masses, is just the first step, and in many cases the easier part, of a discovery. Understanding how such phenomena came to be, is far more ambiguous.

The Relativistic Binary research programme as part of the Meertime Large Survey Proposal has been actively weighing neutron stars across many relativistic binary systems that contain a pulsating neutron star (or pulsar) and a white dwarf or main sequence companion. Optimal results from high precision pulsar timing analysis are achieved by conducting dedicated orbital campaigns during superior conjunction and often at both at UHF and L-band frequencies.

In my talk I will highlight the results of studying a set of relativistic binaries and their implications for NS masses, including PSRs J1933-6211 and J1902-5105. PSR J1902-5105, analysed as part of a student project collaboration, is the most massive NS yet found in MeerKAT data, and at the edge of challenging NS formation theories.

PSR J1933-6211 is a relatively rare system where the analysis of both its kinematic and relativistic orbital parameters, allowed us to fully map the binary's 3D orbital geometry and to obtain accurate mass estimates of both the pulsar and its companion (in spite of the orbital inclination being far from edge-on).

The sensitive MeerKAT measurements solved the mystery of the nature of PSR J1933-6211's companion, and in analogy to the well-studied PSR J1644-2230 binary, strengthens the case for neutron stars being massive not through accreting matter but because, just like how the MeerKAT got its stripes, they were born that way.

A candle in the wind: a radio filament in the core of Abell 3562

Simona Giacintucci
US Naval Research Laboratory

We have discovered a puzzling narrow, long and straight radio filament in the cluster A3562 in a deep MeerKAT observation at 1.28 GHz. This faint filament branches out at a straight angle from the bright tail of a radio galaxy located near the cluster core (at least in projection). The radio thread spans 200 kpc and exactly follows a sloshing cold front seen in the X-rays, staying inside the front in projection. While the tail of the radio galaxy exhibits the expected aging / spectral steepening pattern, the spectral index along the filament is uniform at $\alpha \sim -1.5$. We propose that the radio galaxy is located outside the cold front, but dips its tail in the gas flow under the front. The tangential wind that blows there may stretch the radio plasma from the radio galaxy into a filamentary structure. The uniformity of the radio spectrum along the filament is naturally explained in this scenario. However, to prevent the filament from aging out of the MeerKAT radio band, either the re-acceleration or anomalously fast diffusion of electrons along the stretched magnetic field is needed.

Anomalous HI gas around MHONGOOSE galaxy, NGC 5068

Julia Healy
ASTRON

How galaxies replenish their gas supply in order to sustain star formation, is a research topic of many of the new and upcoming neutral atomic hydrogen (HI) surveys on the SKA precursor instruments. I present recent deep HI observations of NGC 5068, an isolated nearby star-forming galaxy observed by MeerKAT as part of the MHONGOOSE survey. This survey is the deepest HI survey of nearby galaxies until the advent of the SKA and is reaching column densities of NHI (3sigma) $\sim 3\times10^{19}$ cm^{-2} at 11″ to $\sim 7\times10^{17}$ cm^{-2} at 90″ resolution. These deep observations show that the galaxy comprises of three components: a settled, regularly rotating inner disk that is coincident with the star-forming disk, a more chaotic warped outer disk, and a third component that comprises of a number of clouds to the north west of the galaxy that appear to be linked to "fingers" of HI seen stretching out from the inner HI disk. While the origin of these features remains a mystery for now, the dynamics of the main galaxy disk and the warped outer disk, as well as the morphology of the fingers and clouds, do not seem to suggest a previous merger event. It is possible that we are observing accretion of HI onto the disk of NGC 5068.

The Nature of Polarised Sources in MIGHTEE's Deep Fields

Lennart Heino
IDIA/UCT

This study explores the polarised emission of the faint extragalactic radio sources in the MIGHTEE (MeerKAT International Giga-Hertz Tiered Extragalactic Exploration, Jarvis et al., 2016) survey in order to systematically study cosmic magnetic fields in galaxies to high redshift. Tracing the presence and contribution of magnetic fields is an important aspect of understanding galaxy evolution. Reaching a sensitivity of 2 µJy/beam at a resolution of 6 arcseconds, MIGHTEE is providing an opportunity to chart the evolution of polarised emission from distant galaxies over cosmic time.

The MIGHTEE survey detects polarised emission for a large number of radio sources down to total intensity flux densities of the order of 100 µJy. At these flux densities the source population is increasingly dominated by star-forming galaxies (SFGs) as opposed to active galactic nuclei (AGNs) which are dominant at high flux densities. While the radiation from SFGs originates mostly from the products of star formation, the emission from AGNs comes from a central supermassive black hole engine and enormously large relativistic jets that are driven by the gravitational force of the central black hole. Observations of the local universe show that both, AGN and SFG phenomena, are permeated by magnetic fields. Polarised emission of AGN can be traced to very distant galaxies. However, polarised emission of SFGs even at moderate distances has not yet been detected.

We use multi-wavelength criteria to classify MIGHTEE radio objects as either SFG or AGN. We perform Rotation Measure Synthesis (RMSY) on the spectro-polarimetric data cubes and use the polarisation and RMSY spectra to search for polarised emission. A comparative analysis of the polarisation properties of SFGs and AGNs is performed. The analysis is extended to the lowest possible flux densities using stacking techniques. We will show preliminary results of the MeerKAT polarisation studies of radio sources down to a sensitivity at the micro-Jansky level.

From a population of 21479 radio sources down to a total intensity of 150 µJy/beam we detect polarised emission in 408 (1.9%) objects. Of these 349 (85.5%) also show evidence of AGN activity in multi-wavelength data. The remaining 59 objects (14.4%) show no evidence of AGN, and are potentially star-forming galaxies at high redshift. Further investigation is required to confirm the nature of these objects. In addition, we show a polarsation stacking analysis of the faintest sources tracing the AGN and SFG population with cosmic time. Finally, we present the polarisation properties of resolved SFG in the XMM-LSS field.

Discovering variable phenomena by blowing up the data

Ian Heywood
Oxford / Rhodes / SARAO

Image-domain follow-up of transient and variable sources has been a huge success story for MeerKAT, resulting in many publications, including numerous high-impact ones. However, such sources could have been initially discovered by MeerKAT itself if a system for routinely creating a time-series of images was in place. The discovery and false positive rejection potential is expanded further if the full dimensionality of the data is explored, namely the spectral and polarimetric information that the telescope naturally provides in addition to the temporal and spatial dimensions. The computational cost of this can of course be quite significant. I will present some ideas related to this, framing the presentation around some archival MeerKAT observations of some globular clusters.

The dance of radio sources in Abell 1367

Matthias Hoeft
Thüringer Landessternwarte

Cluster mergers give rise to many interesting features, such as large-scale shock fronts that dissipate energy and accelerate electrons to relativistic energies. In addition, the complex relative motions of the active galaxies with respect to the perturbed intra-cluster medium give rise to complex tailed radio galaxies, and stripping of the interstellar medium from star-forming galaxies can also produce long radio tails. A major challenge in understanding the radio relic phenomenon is that the radio luminosity of relics seems to require an unphysically high efficiency of electron acceleration at the shock front, possibly requiring the presence of fossil radio plasma upstream of the shock. A candidate radio relic has been reported in the galaxy cluster Abell 1367. The low redshift of the cluster would allow the object to be studied with excellent spatial resolution, but its large angular scale makes it difficult to recover the full flux density with radio interferometers. MeerKAT, with its many short baselines, allows this relic candidate to be studied in great detail with the telescope. We (Hoeft et al. in prep.) find, based on MeerKAT L-band observations, that the relic candidate coincides with several exceptionally long tails of star-forming galaxies. Using also deep LOFAR observations, we show that the relic candidate is unusual in that it lacks the spectral index gradient typical of radio relics. We speculate that the diffuse emission in Abell 1367 is unique due to the superposition of several stripped star-forming galaxies, possibly re-accelerated by the merger shock. Abell 1367 may therefore provide the first evidence that star-forming galaxies can provide a reservoir of fossil electrons re-accelerated by merger shocks.

Probing Cosmic HI with LADUMA at L-band

Munira Hoosain
University of Cape Town/ South African Astronomical Observatory

The Cosmic Neutral Hydrogen Density (OmegaHI) is a parameter which measures the quantity of neutral hydrogen gas in the universe across cosmic time. Because HI, through its transformation into molecular hydrogen, is the key ingredient for eventual star formation in galaxies, understanding its evolution is crucial for understanding the turnover in the cosmic star formation density at redshift ~ 2. While OmegaHI is well established in the local universe through direct HI measurements and at very high redshifts through observations of damped Lyman-alpha systems, there are very few measurements at intermediate redshifts with small uncertainties. Taking advantage of the sensitivity of MeerKAT, techniques such as spectral stacking, and the depth of the Looking At the Distant Universe (LADUMA) survey, I will present measurements of OmegaHI for $z \leq 0.56$ within the LADUMA field using our first release of L-band data. These results will be compared to other recent measurements from HI surveys to obtain a clearer picture of neutral hydrogen in our universe. LADUMA will thus link the local and high redshift measurements, covering a crucial phase of the universe's history and galaxy evolution.

Luna(tic) Polarimetry with MeerKAT and the JVLA

Benjamin Hugo
SARAO / Rhodes University

We showcase our recent undertaking in modelling 3C286 at frequencies ranging from MeerKAT UHF to JVLA X band. The linear polarization angle of the source is calibrated using measurements of the refraction-polarized thermal radiation at the limb of the Moon, Venus and Mars – the latter two observed with the JVLA. Long term modelling of this source exposed limitations to both ionospheric differential fitting software (using interchange data from international and local Global Navigation Satellite System sites maintained by the Geo-spatial sciences community), and various high cadence global ionospheric electron content model products distributed by various international teams. As a bonus we showcase beautiful high resolution maps of Lunar craters captured with the short-spacing-dominant MeerKAT array at radio frequencies.

Long-period radio transients

Natasha Hurley-Walker
Curtin University / ICRAR

The long-period radio transients are an emerging class of objects characterised by polarised periodic broadband pulses lasting several minutes with periodicities on timescales of tens of minutes. One of the most recent to be published, GPMJ1839-10, has a period derivative that places it below the "death lines" for radio emission from neutron stars (Hurley-Walker et al. 2023) and white dwarfs (Rea et al. 2023). Theoretical frameworks for the radio emission from these unusual objects include magnetars and white dwarf pulsars, although there are significant challenges in reconciling the data with either model.

MeerKAT has been critical in characterising the radio emission from these sources, offering spectral-polarimetric data of unparalleled sensitivity on critical timescales (seconds to tens of minutes) that enables the production of high-quality dynamic spectra of the pulses. This is leading to advances in the modelling of the magnetospheres that must be causing the emission. The high-time-resolution backends such as PTUSE are also essential for understanding the short-timescale behaviour, e.g. the discovery of ms-duration orthogonal polarisation modes in GPMJ1839-10, and will be essential for determining whether such objects are progenitors for Fast Radio Bursts, as predicted by some theories (Wadiasingh et al, 2020; Beniamini et al. 2020).

In this talk I will give an update on our latest observations of these unusual objects, including new MeerKAT data and how it has enabled critical follow up at other wavelengths. I will also discuss how MeerKAT can be used not just for follow-up, but also for discovery, and what that would tell us about the population in our Galaxy.

Nkalakatha: a luminous, high-redshift OH megamaser discovered in early LADUMA observations.

Amir Kazemi-Moridani
Rutgers University

In the local universe, OH megamasers (OHMs) are found exclusively in the centers of infrared-luminous galaxies, implying a connection to gas-rich galaxy mergers, but until MeerKAT came online, no OHM had been detected above a redshift of 0.27. Early observations for the Looking At the Distant Universe with the MeerKAT Array (LADUMA) deep HI survey have achieved the first untargeted detection of an OHM in the main (1665/1667 MHz) OH lines outside the local universe, in a z = 0.52 system nicknamed 'Nkalakatha.' This OHM is remarkably luminous and falls among the brightest OHMs that have been detected so far at any redshift. I will describe the properties of Nkalakatha, what we have learned about it and its host galaxy from followup observations (with MeerKAT, the Very Large Array, and the Hubble Space Telescope), and what its implications may be for using OHMs to study galaxy evolution at higher redshifts.

Star formation as a function of environment in the MeerKAT Galaxy Clusters Legacy Survey

Kabelo Kesebonye
University of Witwatersrand

This study presents the study of star formation rates (SFR) in clusters using dust-unbiased radio luminosities from the MeerKAT Galaxy Clusters Legacy Survey (MGCLS). Probing the star formation (SF) activity of cluster galaxies paves an important path towards our understanding of cluster evolution. Our MeerKAT data is complemented by optical data from the Dark Energy Camera Legacy Survey (DECaLS), for photometric redshifts, and Sunyaev-Zel'dovich (SZ) effect-derived cluster masses from the Atacama Cosmology Telescope (ACT). We present the first statistical study of SFR in clusters using MeerKAT-detected galaxies. We take advantage of the large field of view coverage by MeerKAT to investigate the relation between SFR and the environment in clusters of different dynamical states. Using radio diffuse emission in the form of haloes and relics as a proxy for cluster merger activity, we divide our cluster sample between disturbed/merger clusters and relaxed clusters. We observe a higher fraction of star-forming galaxies (fSF) in disturbed clusters than in relaxed clusters. Disturbed clusters also have higher masses (M200) and total SFR (ΣSFR) in contrast to relaxed clusters. On analysing the redshift evolution of mass-normalised ΣSFR, we observe a $\simeq 4$ times decline in SF activity from redshift of 0.35 to 0.15, corresponding to $\simeq 2$ Gyr in look-back time. Our result is roughly consistent with cluster studies using infrared-derived SFR ($\simeq 5$ times decline) at a similar redshift slice as our sample. We use a subsample of double relic-hosting clusters to investigate the relation between cluster SF activity and the time that has passed since the merger started ($t_{\rm merger}$) estimated from the relic distances from cluster cores. We observe an anti-correlation between ΣSFR and $t_{\rm merger}$, suggesting that younger mergers have a higher SF activity. However, we see no clear correlation in the mass-normalised ΣSFR with $t_{\rm merger}$.

All the, small (and diffuse) things

Dane Kleiner
ASTRON

The combination of exquisite sensitivity and resolution of MeerKAT has enabled the exploration of low column density ($10^{17} - 10^{18}$ cm^{-2}), resolved ($\sim$ a few to tens arcsec) HI emission in the local Universe. I will present results from two MeerKAT Large Survey Programs – The MeerKAT Fornax Survey and MHONGOOSE, that have detected low mass and diffuse HI emission at tens of Mpc. For the first time, we are able to constrain the low mass end of the HI Mass Function (HIMF) in the Fornax cluster. This is the deepest any HIMF has probed and we show that below MHI = 10^7 Msol, the HIMF does not follow a Schecter function. The change in slope is due to the efficient removal of HI from low-mass galaxies, which can occur in only a few hundred Myr once tidal and / or hydrodynamical forces in the cluster act on their

interstellar medium. In the lower density environment, observed in MHONGOOSE, we detect a previously unknown interacting triplet. The diffuse HI emission shows significant extra-planar gas associated with the central galaxy as well as extended HI tails connecting the satellite galaxies. Tidal forces are a clear component of the interaction, however, as the two massive galaxies show undisturbed stellar bodies, the interaction history is likely complex. As suggested by simulations, the gas-rich nature of the triplet may be possible if the triplet is located in a HI-rich region of the cosmic web.

AGN feedback and star formation in a sample of nearby galaxy groups

Konstantinos Kolokythas
NWU

The shallow potential wells of groups bring galaxies into close proximity at low relative velocities, making interactions and mergers common, and making groups perhaps the most important environment for studies of galaxy evolution. However, groups are a diverse class, ranging from spiral-dominated systems rich in HI and molecular gas to more massive, evolved systems dominated by early-type galaxies, with little HI but often hosting an extended hot X-ray emitting intra-group medium (IGM). The transition in gas properties as groups increase in mass is related to the evolution of the galaxy population, with some intermediate systems showing intergalactic HI structures tidally stripped from their spiral members, or even a cold HI IGM. On the other hand, a key environment for the study of AGN feedback is X-ray bright groups, having almost universally short central cooling times and low entropies. Using part of a nearby sample of galaxy groups (the CLoGS sample) we observed using MeerKAT's unprecedented sensitivity and large field of view at the 1.4 GHz band 10 systems in order to examine the neutral hydrogen content of nearby galaxies as well as the continuum emission from the AGN and star-forming galaxies. In the results that I will present, we identify some of the AGN-dominated systems exhibiting additional faint emission beyond the known radio lobes (e.g., from previous outburst cycles), and confirm structures previously only detected earlier in a single band (e.g., the old jet/lobe in NGC 5044), mapping also structures within the jets and lobes at high resolution. In addition, preliminary results of the neutral hydrogen content of the deep HI observations will be presented revealing MeerKAT's sensitivity that allows the tracing of disturbed structures in systems affected by tidal interactions, as well as the fuel supply for star formation.

Unveiling the Hidden Universe along the MeerKAT Galactic Plane Legacy Survey

Renée C. Kraan-Korteweg
University of Cape Town

The deep MeerKAT Galactic Plane Legacy Survey (GPS) covers the whole southern Milky Way along a narrow strip of $\Delta b \sim 3°$. While primarily aimed at exploring the inner Galaxy, the GPS provides a unique opportunity to trace the large-scale distribution of galaxies across the innermost Zone of Avoidance through the spectral 21cm line emission of galaxies. An HI-analysis of the GPS will provide a glimpse into previously hidden parts of the infamous Great Attractor (GA), the Local Void (voids act as repellers), and the Vela Supercluster. These dynamically important structures remain poorly mapped in the ZoA. However, their mass overdensities are crucial in reconciling the decades-long cosmological controversy about the amplitude and volume within which bulk flows arise. With the excellent HI resolution and sensitivity of the GPS (about rms = 0.30-0.60 mJy/beam depending on proximity to the Galactic Bulge), the survey will be sensitive to $M*$ HI galaxies throughout the probed volume ($z < 0.08$, i.e. Vhel < 25,500 km/s), and to galaxies down to the HI-mass limit of $10^{8.5} M_{\odot}$ at the GA distance, as well as the HI-dwarf population in and around the Local Void. Some of the tantalising new results will be presented, such as the prominent signature of a Wall linked to the GA, a clear delineation of the Local Void at these low latitudes, as well as indications of two walls that link to the previously detected higher latitude Vela Supercluster. The GPS survey clearly demonstrates the power of tracing large-scale structures at these extremely low latitudes with deep interferometric HI-surveys, despite the high obscuration and continuum background.

Uncovering extraplanar and anomalous gas in UGCA250 with the MHONGOOSE Survey

Sushma Kurapati
UCT

It is becoming increasingly clear that gas accretion is necessary to sustain the observed levels of star formation rates. A key area of focus lies in the disc-halo interface region which offers insight into gas exchange processes between the disc and the circumgalactic medium. Using HI 21 cm observations from the MHONGOOSE survey, we explore extraplanar gas in edge-on galaxy UGCA250. The combination of high column density sensitivity and high spatial resolution of MHONGOOSE survey enables us to probe the low-column density gas at high resolution. These data reveal that the galaxy UGCA250 has 9 companion galaxies, and the galaxy has a tail-like feature extending southwest up to $\sim$ 34 kpc (in projection). Additionally, we identify a counter-rotating cloud with forbidden velocities, possibly a foreground galaxy. We construct a detailed tilted ring model for this edge-on galaxy to gain a deeper understanding of the vertical structure of its neutral hydrogen. The model that best

matches the observed data cube features a thick disk with a scale height of 3 kpc and an HI mass of about 25% of the total HI mass. Further, we discuss the various possible scenarios for the origin of extraplanar and anomalous gas in UGCA250. This extraplanar gas is detected for the first time in UGCA250 and the HI halo/ thick disc shows structures on various scales.

Chasing Long-duration GRBs with MeerKAT

Tanmoy Laskar
University of Utah

Long-duration Gamma-ray bursts (GRBs), the most energetic explosions in the Universe, are ideal probes of extreme relativistic astrophysics. Observations and modeling of their X-ray to radio afterglow radiation provide crucial clues to understanding particle acceleration in relativistic shocks, explosion and jet launching mechanisms, and the nature of GRB progenitors. Such multi-wavelength studies have previously been hamstrung by the lack of sensitivity of radio facilities. The new synergy between MeerKAT, the VLA, and ALMA has breached a new frontier in GRB studies. I will describe results from five years of MeerKAT observations of GRBs, demonstrating their incredible impact in breaking parameter degeneracies, discovering elusive reverse shock signatures, and uncovering unexpected, new physics in the Universe's most extreme transients.

Enabling New Discoveries in Radio Data with Machine Learning

Michelle Lochner
UWC/SARAO

MeerKAT's incredible sensitivity and resolution has opened up a new window on the universe, leading to an astonishing number of new scientific discoveries. However, as datasets from MeerKAT and other radio telescopes grow in size and complexity, it is becoming increasingly difficult to solve the "needle in a haystack" problem and find rare or new phenomena. In this talk, I will outline Astronomaly, a general anomaly detection framework which combines the experience and intuition of human scientists with the raw processing power of machine learning. I will also highlight some of Astronomaly's recent discoveries including SAURON, a candidate Odd Radio Circle detected in the MeerKAT Galaxy Cluster Legacy Survey data. The discovery of SAURON, and other unusual objects, in this small but rich dataset demonstrates the potential of machine learning to enable scientific discoveries that might otherwise be missed.

Unprecedented polarization results from the MeerKAT Fornax Survey

Francesca Loi
INAF-OAC

One of the goal of the SKA precursors and pathfinders is to release high sensitivity and high resolution images of the faint polarized sky. This will allow us to constrain the origin and the evolution of large scale magnetic fields and to study in detail the properties of the faint radio sky. In this talk I will show how all of these goals can now be pursued with the MeerKAT Fornax Survey (MFS). The MFS is a MeerKAT key science project aiming at studying galaxy evolution (through neutral hydrogen) and the Fornax cluster magnetic field (with broad band spectro-polarimetric data) at L-band. The survey is still on going and with the broad band data acquired so far we obtained the densest number of polarized sources ever detected, i.e. 75 polarized source per square degree over a field of view of 7.069 deg^2. This huge number of polarized sources demonstrate the excellent capabilities of the MeerKAT telescope and allowed us to constrain the properties of the faint polarized sources as well as the intervening large scale magnetic fields.

What have we learnt with MeerKAT on the densest Groups of Galaxies

Verdes-Montenegro Lourdes
Instituto de Astrofísica de Andalucía (CSIC)

Hickson Compact Groups (HCGs) are defined to be galaxy groups composed of 4-10 tightly bound galaxies found in a low-density environment. Their high galaxy density, similar to the centres of rich clusters, leads to strong gravitational interactions among members and acceleration of their evolution. This makes them ideal laboratories for studying galaxy transformation, such as mass assembly pathways and star formation quenching. HCGs can show extreme atomic gas (HI) deficiency. Previous HI studies with the VLA have established an evolutionary sequence: in Phase 1 the gas is mainly within galaxies, while in Phases 2 and 3 more HI gas is progressively missing, either distributed in tidal tails, or missing altogether. The missing gas is (partly) detected by deep GBT observations (spread over up to 1000 km/s), suggesting the presence of diffuse gas in the intragroup medium (IGrM). MeerKAT has the unique capability required to locate and analyse this elusive, diffuse HI. Here we will present the results of our PI program to observe of a sample of HCGs in the intermediate and most advanced evolutionary phases, trying to shed light on how HCGs transition from a complex of HI tidal structures to the stage where all member galaxies completely lose their HI. The MeerKAT sensitivity will tell us whether the transition from Intermediate to late stage groups is accelerated, as suggested by other observations. The large FOV will also give us information on the environment in which the groups are embedded on 1 Mpc scales and how the properties of HCGs correlated with their large scale environment. Our results show a surprising conclusion on the missing HI in the most advanced stage.

A MeerKAT view of the Double Pulsar eclipses

Marcus Lower
CSIRO/ATNF

In addition to making an excellent astrophysical laboratory for testing gravity, the Double Pulsar is also host to a phenomena not seen in any other known double neutron star system. Every 2.45 hrs the fast spinning 'pulsar A' passes almost directly behind the slower spinning 'pulsar B', where it is eclipsed by the relativistic pair plasma trapped within the toroidal magnetic field around pulsar B. Detailed studies of this unique feature have been hampered since the disappearance of radio pulses from pulsar B as spin-orbit precession means its radio beam no longer crosses our line of sight. However, these challenges have since been overcome through combining the stunning sensitivity of MeerKAT with modern statistical inference techniques. In this talk, I will present the first results of our ongoing experiment to monitor the time-evolution of the eclipse envelope. With only 3.5 years of MeerKAT data we have obtained a factor of two improvement in measuring the geodetic precession rate of pulsar B, representing a 6.5% test of General Relativity. I will also describe the implications our updated system geometry has on the radio beam shape of pulsar B and when we may expect to detect it again as a radio pulsar. Lastly, I will show how we can link changes in the polarisation properties of pulsar A through the eclipses to specific line of sight through the plasma-filled magnetosphere of pulsar B.

MeerKAT Search of Dark Matter

Yin-Zhe Ma
Stellenbosch University

Dark matter is the dominant matter in the Universe. In this talk, I will introduce two major scenarios of dark matter widely considered as the dark matter candidates: Axion dark matter and WIMP (Weakly Interactive Massive Particle), and show how the MeerKAT telescope can search and put constraints on their parameters. The first one is Axion, which was originally postulated to solve the strong CP problem in particle physics. Axions can be converted into monochromatic radiation in the neutron star's magnetosphere, constituting a unique window to probe its existence with a radio telescope. We used the MeerKAT telescope for 10 hours to observe the isolated neutron star RX J0806.4-4123 in the UHF band. I will present the results of the constraints on the Axion DM decay rate from the newly observed MeerKAT data. In addition, WIMP dark matter can decay into standard model particles such as quarks and anti-quarks, leptons and anti-leptons which can eventually cascade into radiation in radial bands. We use the L-band MeerKAT telescope to observe the synchrotron emission of WIMP dark matter decay from two dwarf spheroidal galaxies (dSphs; Reticulum II and Tucana III) and obtained strong constraints on WMIP decay channels. I will analyze these two current results and give future prospects on exploiting the entire capacity of MeerKAT to constrain dark matter.

From cold gas to black hole: the AGN duty-cycle as revealed by MeerKAT

Filippo Maccagni
INAF - Osservatorio Astronomico di Cagliari

Active Galactic Nuclei (AGN) are one of the prime drivers of galaxy evolution. It is thought they are triggered by the accretion of cold gas from the interstellar medium (ISM) onto the SMBH. Yet, which processes regulate the gas accretion (feeding) onto the SMBH is unknown, as are the processes that alter the physical conditions of the ISM (feedback), and ultimately change the star formation history of the host galaxy. MeerKAT, with its unique combination of long baselines, dense core of antennas and large field of view, is the one and only instrument able to trace the low-column density neutral atomic hydrogen (HI) flowing in and out of galaxies and connect it to the radio emission ejected by the the nuclear activity, from the circum-nuclear scales to the circum-galactic environments. This allows us to identify how AGN change the physical conditions of the ISM, over which timescales, and how the activity is sustained throughout the lifetime of a galaxy. I will show deep 1.4GHz MeerKAT radio continuum and HI observations of nearby AGN from the large programs MeerKAT Fornax Survey, MHONGOOSE and on-going Open-Time projects. I will focus on powerful radio sources Centaurus A, NGC3100 and Fornax A. In the first, the radio jets are disrupting the HI disk out to its outskirts, where part of the outflowing HI fuels a newly born star forming region. In the latter, I connected the time-scales of the AGN duty-cycle with the fuelling mechanism. While in NGC3100 the nuclear activity is fuelled by HI clouds remnant of a recent interaction, in Fornax A feeding and feedback co-exist in the circum-nuclear regions and self-regulate the rapid recurrent activity. MeerKAT observations of a complete sample of nearby AGN will set the benchmark on studies on the interplay between the cold gas and AGN duty-cycle.

DEEP2@5: Redefining Cosmic Star Formation in the Radio

Allison Matthews
Carnegie Observatories

The peak in the cosmic star formation rate density – at $z \sim 2$ – also marks the peak of dust attenuation, making the full census of star formation activity a measurement fraught with uncertainty. Thankfully, radio emission from normal galaxies – free-free emission of massive stars, and synchrotron emission of relativistic electrons shocked in the supernovae remnants of the same short-lived massive stars emitting primarily in the UV and optical – is entirely unaffected by dust. Unfortunately, star-forming galaxies are such weak radio sources that it is necessary to measure sources at and below 1 microJy at $\sim$ 1.4GHz to add up the majority of ongoing star formation and thus constrain the evolution of the star-formation rate density. Five years ago, MeerKAT produced the deepest radio image to date (DEEP2), and with it we measured radio source counts down to 0.25 microJy, equivalent to the flux density of a

Milky Way-like galaxy at a redshift of 4. The resulting cosmic star-formation rate density derived from our evolutionary models – and an updated FIR/radio correlation—implies that star-forming galaxies evolved more strongly than published inferences from UV and IR data. Having undertaken a spectrophotometric multiwavelength observing campaign of DEEP2, I tested the evolutionary models – derived from source counts – on individual galaxies in specific redshift ranges ($0.2 < z < 1.3$). From the sample of $\sim$ 4000 premium redshifts (<1% uncertainties), we confirm that our global models predict ensemble galaxy evolution remarkably well, and only further the discrepancy with optical/UV measurements of the star formation history of the universe.

21-cm Intensity Mapping with MeerKAT Surveys

Aishrila Mazumder

Jodrell Bank Centre for Astrophysics, University of Manchester

Power spectrum from the 21-cm signal using HI Intensity mapping at low reshift has already been detected using MeerKAT observations of the DEEP2 field. This work will present a follow-up of these detections using the MIGHTEE survey data. We use high spectral resolution MIGHTEE data of the "COSMOS" field to search for HI power spectrum at redshift low redshifts ($0.2 < z < 0.5$). Due to the inherently weak nature of the 21-cm HI signal, it is necessary to characterize the foregrounds and residual systematics that are present in the data. We will discuss these challenges in the context of this data and present some results for power spectrum estimation.

The MeerKAT pulsar timing array: Searches for alternative signals

Matt Miles

Swinburne / OzGrav

The signal that is most sought after in pulsar timing array experiments is that of a stochastic gravitational wave background: the superposition of all nanohertz-frequency gravitational waves emitted in the observable Universe. Recently, a number of pulsar timing arrays have unveiled results indicative of a spatially correlated signal, thought to be a background of gravitational waves from inspiralling supermassive black hole binaries. However, pulsar timing arrays may also be sensitive to single, loud sources emitting in this band. The MeerKAT pulsar timing array, a relatively new endeavor, possesses a short timing baseline which limits the extent to which it can constrain the spectral characteristics of a stochastic background. However, if a single source, such as an isolated supermassive black hole binary, radiates at a frequency that the array is sensitive to, an extended observational time-span may not be a prerequisite for a detection. Through careful and rigorous modelling of all signals in the array's data, we can eliminate the possibilities of spurious detections

of any common signal, and build confidence that searches for more exotic signals are possible. We present the first analysis of correlated signals in the MeerKAT pulsar timing array from the perspective of emission from a solitary source, rather than from an isotropic background.

The MeerChoirs View of HI in Galaxy Groups

Moses Mogotsi
SALT, SAAO

MeerChoirs is a HI survey of nearby (23-151 Mpc) galaxy groups selected from SINGG. The groups were observed in the H-alpha, R-band and UV, and they cover a wide range of compactness, number of members, HI-richness and group evolution. Therefore, their constituent galaxies are in a wide range of environments. MeerKAT provides an unprecedented combination of high sensitivity, spatial resolution and wide field of view; this is ideal for resolved observations of large and dwarf galaxies, and the intra-group medium of these groups. This is highlighted by how the initial results from the survey have identified many HI sources in our groups, and large amounts of gas outside of some of the galaxy discs. In some cases the intra-group gas is more massive than the magellanic clouds, and we detect many signatures of gas inflows and inflows. These observations are the best to date of these groups and are key to understanding the flow of baryons and fuelling of star formation in group galaxies. I will be presenting the results from our work and how MeerKAT is proving to be an excellent instrument for such studies.

Discovering rare radio transients with MeerKAT and ASKAP

Tara Murphy
University of Sydney

The past decade of work in radio transients has determined that only a few percent of radio sources are highly variable and even fewer ($< 0.1\%$) are highly circularly polarised. These variable, circularly polarised sources tend to be objects of interest: radio stars, pulsars or unusual sources such as Galactic Centre Radio Transients (GCRTs) or ultra-long period magnetars.

In the first few years of Australian SKA Pathfinder (ASKAP) pilot surveys (and now full operations) we have used the combination of variability and circular polarisation to discover a number of rare and interesting objects. For example, the most luminous pulsar in the Large Magellanic Clouds; the coolest T-dwarf detected in radio, and a new GCRT. In each of these cases, MeerKAT has been central to identifying and analysing these sources.

ASKAP is a discovery machine, but to confirm the source type of new objects, further follow-up is required. In particular, MeerKAT, with its sensitivity and capability to do simultaneous imaging and beamformed observations has been critical.

In this talk we discuss our results so far, and how the synergies between MeerKAT and ASKAP will be key to further developments in radio transients, on the path to the SKA.

Exploring the interstellar medium using pulsars: how MeerKAT pulsar observations reveal the structure of our galaxy

Lucy Oswald

University of Oxford

Much of the Milky Way is made up of material that we cannot see. However, MeerKAT pulsar observations give us a way to examine its structure and properties, through measuring the impact of the interstellar medium (ISM) upon these observations. The Thousand-Pulsar-Array project, part of the MeerTime Large Survey Project on the MeerKAT telescope, provides a vast array of sightlines through the ISM, so that large-scale galactic structures can be revealed. In this talk, I will present the results of multiple new measurements and studies of dispersion, Faraday rotation, scintillation and scattering of the Thousand-Pulsar-Array dataset. I will discuss what these results tell us about the plasma structures, turbulence and magnetic field structures of the ISM on a variety of scales, and highlight the impact that the MeerKAT telescope has had on advancing our understanding of the Milky Way.

Inspecting Fast Radio Bursts through MeerKAT's lens: high space and time resolution studies

Inés Pastor-Marazuela

University of Manchester

The field of the enigmatic Fast Radio Bursts (FRBs) is currently booming. These extragalactic, millisecond-duration radio transients are now discovered in the hundreds, with tens being localised to the galaxies where they were produced, and fifty being known to repeat. This begs the question, do we already have enough information to identify what is producing them? Since the detection of a bright radio burst emitted by the galactic magnetar SGR 1935+2154, we know some must come from magnetars. However, the dichotomy between one-off and repeating FRBs remains unsolved, and different emission mechanisms could be at play. To establish the progenitors of these mysterious transients, it is fundamental to conduct detailed spectro-temporal analyses and to achieve precise localisations of the FRBs. The MeerTRAP project was conceived to leverage MeerKAT's high sensitivity and angular resolution to look for galactic and extragalactic radio transients. Since 2019, MeerTRAP has found more than forty – so far non-repeating – FRBs. When a new bright FRB is detected, 300 ms of raw voltage data are stored, which permits an arcsecond precision localisation and enables us to study the bursts at the

highest time and frequency resolution. In this talk, I will present the latest MeerTRAP FRBs that we have localised to their host galaxies, which constitute a sample of high-redshift FRBs. From the properties of the galaxies where the FRBs were formed, we can infer crucial information about their progenitors and the environments where they live. Additionally, the bursts display complex spectro-temporal structures, high linear polarisation fractions and a wide range of rotation measures, which could be interpreted in terms of a magnetospheric origin. Overall, I will detail how these properties help us discern the nature of FRBs.

MPIfR-MeerKAT Galactic Plane Survey (MMGPS) I: System setup and early results

Denisha Pillay

Max planck institute for radio astronomy

Pulsars are highly magnetised, rapidly rotating neutron stars that emit beams of electromagnetic radiation from their magnetic poles and are remarkable laboratories for testing theories of gravity, studying neutron star interiors, and constraining equations of state. Previous surveys searching for such intriguing objects have provided high-impact science results, and new-generation radio telescope sensitivities enable more intriguing discoveries. The Max-Planck-Institut für Radioastronomie (MPIfR) MeerKAT galactic plane survey (MMGPS) is an ongoing commensal survey that aims to maximise the scientific return per unit of MeerKAT observing time by covering multiple science cases (pulsars, fast transients, Galactic and extragalactic magnetism and Galactic star formation) simultaneously. In this talk, I will describe the pulsar search system setup and early results. The primary science objective of the MMGPS is to find previously undetected compact relativistic binary pulsars along the Galactic plane and use such systems to probe general relativity in the strong field regime. The MMGPS has been partitioned into three parts: the MMGPS-L band (1.4 GHz observations of the Galactic plane), MMGPS-S band ($\sim$2.4 GHz observations close to the Galactic plane) and MMGPS-SgrA* (high-frequency end of S-Band ($\sim$3 GHz) observations centred on Sagittarius A*). The L-band portion of the survey has been completed, yielding 74 pulsar discoveries (16 binary systems and 2 double neutron star systems) and the S-band portion of the survey is currently underway.

Studying the Circumgalactic Medium with MeerKAT

D.J. Pisano
UCT

In order to understand how galaxies accrete gas from their surroundings and the impacts of feedback on quenching this accretion, it is necessary to study the circumgalactic medium (CGM). While we have estimates of the total mass and metallicity of the CGM from UV absorption line studies, in order to understand the flow of gas onto and out of galaxy disks in the local universe, we need to use atomic neutral hydrogen (HI) observations to map these processes. For the first time, MeerKAT allows us to probe the CGM with sufficient sensitivity and resolution to constrain models of accretion and feedback. I will present results from my research group's work in studying the CGM from individual galaxies observed as part of MeerKAT open time and large survey projects and our plans for the future.

MeerKAT view of the largest particle accelerators of our Universe

Kamlesh Rajpurohit
Harvard-Smithsonian Center for Astrophysics (CfA), USA

Galaxy clusters undergoing major mergers host spectacular megaparsec-scale diffuse radio sources called radio relics and radio halos. They are believed to originate from cosmic-ray electrons which are (re-)accelerated by merger-driven shocks and turbulence in the intracluster medium (ICM). However, we do not yet have a clear understanding of the particle acceleration processes responsible for their origin and the microphysics involved in the interplay between different components of the ICM. The advent of cutting-edge radio telescopes like MeerKAT and SKA precursors is revolutionizing our understanding of the Universe. They permit wideband spectro-polarimetric observations with unprecedented sensitivity and remarkable spatial resolution, thus allowing to investigate finest details. We present results obtained with high-resolution MeerKAT UHF and L-band observations of four highly disturbed clusters, revealing complex radio morphology, intriguing filaments, diffuse emission on a very large scale (> 3 Mpc), a multicomponent halo, and puzzling relations between radio and X-ray quantities. Our findings provide crucial insights into the underlying particle acceleration mechanisms, the complex interplay between thermal and non-thermal plasma, and the magnetization of the ICM.

Probing the Macquart relation with SKA precursors: A sample of high-DM Fast Radio Bursts discovered by MeerKAT

Kaustubh Rajwade
ASTRON

Fast Radio Bursts are a recent phenomenon in time-domain radio astronomy that have taken the field by storm since their discovery more than 15 years ago. Their cosmological nature has allowed astronomers to probe fundamental open questions in modern Cosmology, making FRBs excellent tools to solve existing problems in Astrophysics. An important question that FRBs are able to answer is finding the missing baryons in the Universe. By measuring the dispersion measures; the total integrated electron column density along the line of sight, one gets valuable insights into the distribution of electrons in the Universe. This is characterized by the Macquart relation; the relationship between the dispersion measure due to the inter-galactic medium (IGM) and the red-shift of the FRB. New discoveries of far-away FRBs by SKA precursor facilities are slowly starting to probe this never-before-explored parameter space of the electron distribution at large redshifts. In this talk, I will present a sample of high-DM FRBs discovered with MeerKAT that probe the electron distribution at high redshifts. I will talk about the state-of-the-art FRB detection and rapid localisation system that made these discoveries and measurements possible. I will give an overview of the recently deployed transient buffer system, that allows us to save raw voltages from MeerKAT to enable fast localisation and host galaxy identification. I will then present a sample of FRBs that possess large DMs, discuss their measured redshifts, and finally, present implications of their locations wrt to the Macquart relation and what these new findings tell us about a rather unexplored parameter space in the electron distribution of the IGM.

The Gas Tails in MeerKAT Clusters

Mpati Ramatsoku
Rhodes University

Understanding the origin and working modes of the cessation of star formation in galaxies that leads to the passively-evolving population is vital in galaxy evolution studies. The environment of galaxies is a critical aspect of these investigations, as the fraction of star-forming galaxies is the lowest inside galaxy clusters. At the same time, the fraction of passive galaxies is the highest. Several physical mechanisms are responsible for quenching star formation at higher frequencies in clusters relative to the field. One of the main mechanisms is ram-pressure stripping (RPS) which occurs as galaxies fall and interact with the intracluster medium (ICM). Examples of galaxies transforming due to RPS are jellyfish galaxies that exhibit long gaseous tails stripped from the galaxy disc. In this talk, I will discuss the largest sample of HI gas tails to date in diverse environments of clusters from the MeerKAT Galaxy Cluster Legacy Survey. The work to be presented attempts to

study the physical conditions required to form such strongly ram-pressure-stripped galaxies, i.e., physical properties of the galaxies, infall speed and times, and physical properties of the surrounding ICM.

Studying the Galactic Center with MeerKAT S-Band Receivers and the Search for Pulsars

Isabella Rammala

Max-Planck-Institut für Radioastronomie

During its inauguration, the MeerKAT released, to date, the most detailed image of the centre of the Galaxy at L-band (1.28 GHz). Since then, the data have been exploited for various scientific research. One such exploitation was the catalogue of unresolved point sources. Over 1500 sources were identified, of which 20 are steep spectrum point sources (with spectral index < -1.8). This work was motivated by the search for radio pulsar candidates in the continuum domain which, when visible, will be observed as point sources, with an expected steep spectra. The expectation comes from the observed average spectral behaviour of the known radio pulsars. Additionally, radio pulsars are known to have highly linear polarised emission, with some exhibiting circular polarisation. We use the S-Band receivers to survey Galactic Centre region at S1 (2.4 GHz) and S4 (3.1 GHz), with the intent for polarimetric studies of the Radio Arc bubble, Sgr A and B regions, as well as the newly catalogued point sources. The continuum data is recorded while simultaneously placing tied-array beams onto the catalogued point sources to search for any periodicity in the time-domain. We present the S-Band images and the catalogue of interesting sources based on their polarisation properties, as well as the initial time-domain search for pulsations. We also discuss the design and specifications for the future-planned deep search for radio pulsars within one parsec of Sgr A* at S4.

A MeerKAT S-band view on the DEEP2 field

Shilpa Ranchod

Max-Planck-Institut für Radioastronomie

The integration of S-band receivers into MeerKAT significantly enhances the telescope's spectral coverage and angular resolution, allowing for the detailed study of morphologically interesting AGN and star-forming galaxies. In addition, it enables deeper observations for population studies of such sources, given the significantly lower confusion limit. We present the first continuum imaging results with the MeerKAT S-band, observations of the DEEP2 field in the S1 (1.96 – 2.84 GHz) and S4 (2.62 – 3.50 GHz) sub-bands using a total of 55 antennas. With an on-source integration time of just 65 min, the S1 (S4) image has an angular resolution of $7.1'' \times 3.2''$ ($5.0'' \times 2.2''$) and a sensitivity of 8.7 (7.8) µJy/beam. We present the Euclidean-normalised source counts for this field, as well as an in-depth morphological comparison of resolved sources in both the L-band (Mauch+2020) and S-band

images. These observations provide an important demonstration of the capabilities of the MeerKAT S-band with relatively short integration times, in comparison with existing S-band surveys, and speak to the rich scientific potential of future MeerKAT and MeerKAT+ full-Stokes S-band surveys.

MeerKAT's incredible tomographic view of interstellar plasma and a pulsar bow shock

Daniel Reardon

Swinburne University of Technology

Radio emission from pulsars is scattered by density fluctuations in the turbulent ionised interstellar medium. The scattered waves constructively and destructively interfere, which manifest as brightness variations, scintillations, in time and frequency. A power spectrum of the scintillation often shows striking parabolic arcs, with a curvature that pinpoints the location of the turbulence. In this talk I present the most sensitive survey of interstellar scintillation arcs towards a single source, through observations of the brightest millisecond pulsar, PSR J0437-4715, captured with the MeerKAT radio telescope. We observe at least 20 independent scintillation arcs, and provide the geometric models for 17. Each arc corresponds to a localised over-density of plasma along our line of sight towards the pulsar. Three of the arcs, with extremely low curvatures, originate from the pulsar's bow shock and provide a tomographic view of internal shock structures. The measured distance to the forward shock solves its geometry and the pulsar's space velocity in three-dimensions, while the measured internal shock velocities identify one arc as originating from the termination shock. The abundance of scintillation arcs towards such a nearby source, likely within the local bubble, demonstrates the ubiquitous presence of thin scattering screens in interstellar plasma.

The TRAPUM Globular Cluster pulsar survey: a wealth of discoveries made by MeerKAT leads a new renaissance of the field

Alessandro Ridolfi

INAF - Osservatorio Astronomico di Cagliari

Globular Clusters (GCs) are renowned to be the hosts of a wealth of radio pulsars, the vast majority of which are millisecond pulsars (MSPs). The extreme stellar densities characterizing the central regions of GCs promote the formation of binary systems where neutron stars (NSs) can be recycled. On the other hand, the high probability of gravitational interactions between stars also favors the disruption of previously formed binaries, as well as the exchange of companions, leading to the formation of pulsars and binary systems with extreme or unconventional properties. Since 2019, MeerKAT has been searching for new pulsars in GCs within its TRAPUM (Transients and Pulsars with MeerKAT) globular cluster pulsar survey

programme. Its superb sensitivity, combined with state-of-the art beamforming and data acquisition capabilities, has so far allowed MeerKAT to discover over 80 new pulsars in 15 different clusters. Several of these pulsars present extreme, and in some cases unique, characteristics. At the same time, many of the targeted GCs have seen their known pulsar population increase dramatically, enabling new studies of the host cluster structure. All of this has led to a new "renaissance" of the science of pulsars in GCs. In this talk, I will present the TRAPUM GC pulsar survey. After describing the target selection, observing strategy and data analysis techniques used, I will discuss some of the major results obtained so far. As the survey has recently entered a new phase, with observations now being taken also with the new "S-band" receivers and also targeting GCs with no previously known pulsars, I will provide some insights into the new challenges and opportunities that this is bringing. Finally, I will highlight the synergies between MeerKAT and other radio facilities, which turned out out to be crucial to maximize the scientific potential of the new discoveries.

New insights on accretion and AGN feedback from deep MeerKAT L-band observations of two nearby late-type galaxies.

Karina Santana

University of Witwatersrand (Wits)

The replenishment of cold gas into late-type galaxies is required to sustain their star formation rate densities over cosmic time, however, observational evidence remains ambiguous. MeerKAT observations of nearby galaxies (DL<200 Mpc) are providing new unique insights on the neutral atomic hydrogen (HI) gas morphology and kinematics from circum-galactic to circum-nuclear scales of galaxies, contributing to our understanding on how gas flows in and out of galaxies are responsible for the fueling of star formation (SF) and active galactic nuclei (AGN). I will present deep MeerKAT L-band observations of two nearby galaxies (NGC 6240 and NGC 5643) where we detect HI clouds and filaments that enable us to trace the interaction history of the galaxies and the gas flows onto their disks.

MeerKAT observations of NGC 5643 trace the dense HI correlated with the star formation in the spiral arms and several external low-column density features, including a tail that is strongly counter-rotating with respect to the disk and extends well beyond the systemic velocity of the galaxy, likely indicating cold gas accretion from the environment. NGC 6240 is a prototypical post-merger system showing on-going dual nuclear activity and starburst-driven gas outflows/inflows. MeerKAT observations trace the interaction history of the galaxy and allow us to connect it to the triggering of both merging SMBHs in NGC 6240. In the innermost kilo-parsec of both NGC 5643 and NGC 6240, HI absorption may trace the neutral atomic counterpart of the multi-phase AGN outflow.

These studies are a prototypical example of how MeerKAT observations provide a new multi-view of gas flows in galaxies and their impact on star formation and nuclear activity.

MeerKAT's view of cluster-scale faint diffuse emission

Sinenhlanhla Sikhosana
University of KwaZulu-Natal

Radio observations of galaxy clusters reveal cluster-scale faint diffuse synchrotron emission that is not associated with individual galaxies but rather with the intra-cluster medium (ICM). The formation of these radio sources, categorised broadly as radio halos, relics and phoenixes, is linked to merger-induced turbulent activity in the ICM. The formation theories postulate that a significant number of halos at high redshift is characterised by ultra-steep spectra and low luminosities because of increasing inverse Compton energy losses. In this talk, I will present the highly sensitive MeerKAT observations of the diffuse emission in the Bullet Cluster, which unveiled previously undetected regions of the radio halo (reported in Sikhosana et al. 2023). Furthermore, correlation studies of non-thermal radio halo and thermal X-ray emissions produce a linear slope. This linear slope supports the cosmic ray re-acceleration theories, as derived in the initial study by Govoni et al. 2001. Finally, I will present a new detection of a radio halo at redshift 1.23, which makes it the highest redshift halo detected to date (Sikhosana et al. in prep). Such a detection challenges our theoretical understanding of the origin of radio halos.

Jove & the PARROT: MeerKAT as a dynamic imaging machine

Oleg Smirnov
Rhodes University

With the increased sensitivity and field of view of SKA pathfinders, dynamic imaging (that is, imaging the time axis) is becoming a burgeoning field yielding rich new discoveries of transients and variable sources. MeerKAT is capable of reaching sub-150 μJy image rms in an 8s integration, which opens up studies of variability on much shorter timescales than possible with any other past or present instruments. At the same time, imaging at such short timescales introduces its own substantial challenges. Instrumental effects that tend to average out in a traditional long synthesis observation can become limiting for dynamic imaging if not addressed correctly.

I will present MeerKAT dynamic imaging of Jupiter's radiation belts, which has led to the serendipitous discovery of a new neutron star tentatively called a PARROT (pulsar with abnormal refraction occurring on odd timescales). I will discuss the calibration and imaging challenges inherent to dynamic imaging. I will also present imaging pipelines that are capable of yielding light curves and, potentially, dynamic spectra for thousands of field sources en masse, potentially turning MeerKAT into a "variability mining" machine.

The MeerKAT single-pulse census of the pulsar population: What do 1.6 million pulsar pulses tell us?

Xiaoxi Song
ASTRON

As part of the Thousand-Pulsar-Array programme on MeerKAT (part of the MeerTime Large Survey Project), we carried out a big survey to study the pulse shape variability from pulse-to-pulse in 1198 pulsars. The great sensitivity of MeerKAT helped to reveal a wealth of phenomena, including periodicities known as drifting subpulses. We used a semi-automated pipeline to analyse the more than 1.6 million recorded pulses in a systematic way. We find that drifting subpulses are very common: more than half of the overall population of pulsars would have detectable drifting subpulses if high enough quality data would be available. This large study reveals the evolution of drifting subpulses across the pulsar population in unprecedented detail. In particular, it is found that the modulation period evolves non-monotonically over the lifetime of pulsars. The non-monotonic evolution strongly suggests that young pulsars possess aliased fast intrinsic modulation (with a period faster than the Nyquist period of 2 pulse periods). This would also explain why the subpulse modulation patterns of young pulsars are more erratic. Modelling drifting subpulses as subbeams rotating about the magnetic axis of the pulsar, their circulation must slow down as the pulsar evolves. This is the opposite to what is expected if circulation is driven by an ExB drift, so in contradiction with the text-book explanation of drifting subpulses. This can be resolved if the observed periodicity is due to a beat between an ExB system and the pulsar period. Finally, in this talk various on-going spin-off projects will be briefly described, thereby giving a flavour of the richness of the obtained survey data.

A MeerKAT exploration of X-shaped Radio Galaxies

Kshitij Thorat
University of Pretoria

SKA pathfinders and precursors have, over the past few years, uncovered radio galaxies with unforeseen morphological features and revealed unknown aspects of sources we thought we knew very well. We may expect to find larger populations of what for now are rare sources, thus shedding light on some of the current astrophysical mysteries. X or Z shaped radio galaxies are examples of such sources; inversion-symmetric and showing two axes of emission as compared to a single axis in the more usual radio galaxies, their origin scenarios are a mystery and include SMBH mergers and hydrodynamical backflows, which have wider astrophysical and cosmological implications. Recent broadband, sensitive observations with MeerKAT, ASKAP and LOFAR have thrown more light on these sources allowing for pixel-by-pixel spectral index analysis, a tool which may help ascertain the mechanisms behind the formation of these sources. In this talk, I'll present the results of imaging a sample of X and Z shaped radio galaxies observed in MeerKAT L-band. In

particular I'll discuss the imaging and data analysis using CARACal pipeline and derivation of spectral index and spectral age maps. These data make possible an estimation of the possible origin scenarios applicable for the sample sources. In the final part of the talk, I'll present the case for how multiwavelength studies of larger samples are key in advancing our understanding of such sources and how ML techniques may be able to help us in this endeavour.

The quest for hidden populations of evolved massive stars with MeerKAT

Grazia Umana
INAF

The evolution of disk galaxies is strongly influenced by their populations of massive stars, which through their copious and energetic stellar winds provide both processed material and energy to the ISM, triggering the formation of new generations of stars. The intense UV fields and conspicuous mass-loss of massive stars heavily alter the morphology of the local ISM, leaving an unmistakable footprint onto their surroundings: from large cavities, carved out in nearby molecular clouds, to dense, expanding circumstellar nebulae of dust and gas.

Despite the undeniable relevance of massive stars, the details of their post-MS evolution are far from being completely understood. Theoretical models predict a succession of rapidly evolving, unstable transitional stages towards their inevitable end as core-collapse supernovae. Still, many questions regarding these intermediate evolutionary phases remain open, and the only observational support for these models comes down to a handful of objects in each stage. Therefore, finding and characterizing new evolved massive star candidates emerges as a very critical yet complex task.

Radio observations are a very convenient ways to investigate the footprint of evolved stars, thanks to the ability of radio waves to penetrate the obscuring matter in the line of sight, that may hamper the detection at shorter wavelengths.

In this talk, results from our quest for massive evolved stars will be presented. MeerKAT, thanks to its superb sensitivity, angular resolution and uv coverage, has already proven to be the ideal instrument to unveiling hidden populations of evolved massive stars. MeerKAT has revealed a radio continuum sky rich in structures associated with massive stars. Dozens of extended continuum structures linked to WRs and LBVs have been found in the SARAO MeerKAT L-band Galactic Plane Survey and many other new rings and shells, with no matching entries in catalogues of known evolved objects, have been identified.

Enhancing discovery in the MeerKAT Galaxy Cluster Legacy Survey with Machine Learning

Fernando Ventura
University of Pretoria

The aim of this project is to identify unusual radio sources with astrophysical value in the MeerKAT Galaxy Cluster Legacy Survey (MGCLS), a SARAO Science Legacy Survey that observed 115 galaxy clusters at 1.28 GHz with $\sim$ µJy/beam brightness sensitivity. We use autoencoders, which are automated unsupervised neural networks that encode an input into latent space code form and then attempt to reconstruct the input MGCLS image. Our approach to find source morphologies of interest in upcoming surveys is key to optimal science exploitation of the expected large number of such sources that can be observed by SKA and precursor instruments. Which, coupled with the dramatic increase in recovered source complexity with MeerKAT's excellent imaging fidelity and dynamic range, makes it challenging for traditional tools to keep up with high source density and the Big Data paradigm. The use of machine learning is a promising approach to addressing many of the challenges these high-quality images present. In addition to the technical approach, we present some of the science results from this project, demonstrating that autoencoders can significantly reduce the work required to locate astrophysically valuable sources.

Radio tails of ram-pressure stripped galaxies in the harsh environment of the Shapley supercluster

Tiziana Venturi
INAF, Istituto di Radioastronomia

The Shapley Supercluster, located in the Southern Hemisphere at an average redshift of $z \sim 0.048$, is one of the largest bound superclusters in the nearby Universe, where the effects of interacting and merging clusters can be witnessed, going from the large Mpc-scale footprints of diffuse emission within and in-between galaxy clusters, to the kpc-scale signatures in individual galaxies. Thanks to the sensitivity and u-v coverage that MeerKAT can cover, the Shapley Supercluster is now a key target for astrophysics. In this presentation we focus on four new radio continuum tails associated with ram-pressure stripped (RPS) galaxies which are members of the Shapley supercluster. Tails of radio emission in late-type galaxies have remained elusive so far, due to their low surface-brightness, and thanks to the current observational radio facilities only recently their detection has grown in number. Our study is based on 1.2 GHz Meerkat observations and multi-band radio data from other SKA precursors and pathfinders. Our deep and high-resolution radio continuum multiband imaging of the merging clusters in the Shapley Supercluster provides, on one side, detailed descriptions of the cluster merger features tracing the intra-cluster diffuse non-thermal emission, on the other side, it reveals the radio continuum tails of individual galaxies. Here we show the properties of the RPS tails in the Shapley supercluster and investigate the cause-effect relationship, i.e. the link between the

large-scale mass assembly and the involved galaxies. We can now address the open issues about the nature and origin of the radio tail in RPS galaxies and how the radio continuum emission in the tails correlates with the emission in other bands and with the galaxy environment.

The MeerKAT + South Pole Telescope UHF Survey of the distant universe

Joaquin Vieira (presented by R. Deane)
U. Illinois at Urbana-Champaign / NCSA

The past two decades have demonstrated a clear synergy between wide-area, high-sensitivity cm- and sub/mm-wave surveys to probe fundamental problems in galaxy evolution and cosmology. We harness the synergy between the South Pole Telescope (SPT) and MeerKAT, by carrying out a deep (10 μJy/beam), wide (100 sq. deg) survey in the UHF band. The two primary science goals are: (1) multi-wavelength counterpart identification of mm-wave sources in the SPT Deep Field; and (2) the selection of $z > 5$ dusty star-forming galaxies. Commensal and serendipitous science cases include the study of luminous, dust-obscured active galactic nuclei, the study of galaxy clusters, high redshift measurements of the radio-FIR correlation, the discovery of exotic radio morphologies, cross-correlations with CMB lensing maps, the cross-correlation of HI with CII across the peak of cosmic star formation, the discovery of high-redshift neutral hydrogen absorption systems, and radio detections of strong gravitationally lensed sources. This survey sits in a unique and highly complementary part of the frequency, areal, and depth parameter space for SKA Pathfinders/Precursors, and will undoubtedly have legacy value well into the SKA era. In this talk, we present an overview of the science case, survey strategy and data processing progress, as well as early science results.

Measuring the cosmic radio dipole with MeerKAT

Jonah Wagenveld
Max Planck Institute for Radio Astronomy

The cosmic radio dipole is an anisotropy in the number counts of radio sources with respect to the cosmic background. Results have shown a tension between the radio dipole and the dipole as measured from the cosmic microwave background (CMB), presenting an intriguing puzzle as to the cause of this discrepancy. With its high sensitivity and large field of view, each MeerKAT pointing can yield thousands of sources observed in continuum. The MeerKAT Absorption Line Survey (MALS) is a blind search for absorption lines with pointings centred on bright radio sources. We present a dipole measurement carried out on the continuum catalogue of all 391 MALS pointings observed in L-band. The catalogue produced from these pointings covers 1623 square degrees and contains around 800,000 sources. We present the characterisation of completeness and noise properties of the catalogue, as well as

novel dipole estimators developed for this measurement. We discuss the challenges that came along with a measurement of the dipole on MALS in the form of some persistent systematics. We discuss some of these systematic effects present in the MeerKAT data and their possible causes, and how these could be addressed for MALS and other surveys that aim to do large scale cosmology.

A first look at MIGHTEE quasars

Sarah White
Rhodes University

I will present analyses of radio emission from quasars in the MeerKAT International GHz Tiered Extragalactic Exploration (MIGHTEE) fields, the majority of which are 'radio quiet'. Being at low radio-luminosities, it has been assumed that their emission is dominated by star formation, but previous multiwavelength analyses (White et al., 2015, 2017) led to controversial evidence that black-hole accretion makes a significant contribution towards the total radio emission from this type of active galactic nucleus (AGN). Due to the greater level of sensitivity that MeerKAT provides, we are able to detect a larger fraction of star-formation-related radio emission (White et al., in prep.), with further analysis being required. This includes careful consideration of the empirical scaling relations that are used to infer the fraction of AGN-related emission, as well as the impact of the quasar-selection criteria on the conclusions that are drawn. Such analyses have important implications for determining the accretion and star-formation histories of the Universe, and for creating robust samples of radio-quiet AGN. This then allows us to better-investigate the accretion and feedback processes taking place within this poorly-studied subset of the AGN population.

The radio properties of high-redshift AGN and galaxies in the MIGHTEE survey

Imogen Whittam
University of Oxford / UWC

I will discuss recent work investigating the properties of $3 < z < 5$ galaxies and active galactic nuclei (AGN) using the MIGHTEE survey. MIGHTEE is a galaxy evolution survey currently underway with the MeerKAT radio telescope. Once complete, the survey will cover 20 square degrees in four fields to a depth of $\sim$2 μJy rms/beam at 1.3 GHz, providing a unique combination of depth and breath. Crucially, the MIGHTEE fields have excellent multi-wavelength coverage, enabling a full census of galaxy properties. I use high-redshift samples selected in the optical and near-infrared from the VIDEO survey and stack the MIGHTEE continuum data at the positions of these sources. This enables me to determine: 1) the total star-formation rate of these sources from the radio data 2) the impact of AGN within these sources and 3) the evolution of these properties to the highest redshifts. This work is key to

understanding the impact of dust obscuration in highly star-forming galaxies, and the transition between star-formation dominated and AGN-dominated sources at $z \sim 4$, which is poorly understood.

Radio emission from Cataclysmic Variables: new insights from 5 years of MeerKAT observations

Patrick Woudt

University of Cape Town

Over the past 5 years, the ThunderKAT large survey project on MeerKAT has observed a representative sample of nearby Cataclysmic Variables (CVs); accreting white dwarfs in close compact binaries. Dwarf novae are non-magnetic CVs that display periodic outbursts due to a thermal-viscous instability in the accretion disk, leading to short periods (days to weeks) of enhanced mass transfer onto the white dwarf. Whilst these systems are the dominant population in optical transient surveys, their radio emission is inherently faint and remains poorly understood. ThunderKAT has quadrupled the number of dwarf novae detected at L-band during outburst, all showing repeatable behaviour across multiple outbursts in both L-band and S-band. In the first part of this talk I will give an overview of the main results from the CV component of ThunderKAT and highlight the new insights gained from 5 years of MeerKAT observations.

The unique capability of MeerKAT to study accreting white dwarfs in compact binaries across a range of time-scales (seconds to years) is further demonstrated by the remarkable MeerKAT observation of narrow pulsed emission from the second known white dwarf pulsar, J1912-4410. This is the first white dwarf to show pulsar-like narrow pulsed emission at radio frequencies, akin to neutron star pulsars. This system is thought to represent an evolutionary stage in accreting magnetic CVs. In the second part of this talk I will present the MeerKAT observations of J1912-4410 – a white dwarf pulsar in a compact binary – and discuss the potential of fast (2-sec) commensal imaging searches with MeerKAT to unveil additional white dwarf pulsars in the Milky Way.

Posters

A MeerKAT view of pulsars in globular clusters: exotic systems, magnetic fields and non-luminous masses

Federico Abbate
INAF - OAC

The presence of a large population of exotic pulsars within globular clusters (GCs) presents a unique opportunity to study the properties of the pulsars and of the GCs themselves. The high concentration of these pulsars and the beamforming capabilities of the backends at MeerKAT allow us to observe all the pulsars in a GC simultaneously. Thanks to this, multiple scientific avenues in different fields can be explored at once.

Within the large survey project MeerTIME, an important number of hours have been devoted to these objects with significant results. The results cover a wide range of topics like the determination of orbital parameters for exotic binary systems, the study of giant pulse emitting pulsars, the first study of multiple consecutive eclipses, the detection of a magnetic field within the gas of a GC and the modeling of the non-luminous mass content in the cores of GCs.

Searching for Extended HI Emission in the Fornax Cluster

Nabeelah Adam
UCT

The MeerKAT Fornax Survey is mapping the Fornax cluster over 12 square degrees down to an HI column density of 10^{18} atoms per square kilometer in an attempt to study the cluster environment and its effect on HI distribution within the cluster. By looking at both MeerKAT and GBT data, I aim to study the lowest column density HI within Fornax with specific interest in the interactions between galactic neighbours and overall cluster dynamics/interactions (i.e. looking for HI tails, intracluster HI).

MeerKAT+VLA+GMRT+LOFAR: Radio spectral properties at 150-5000MHz of star-forming galaxies

Fangxia An

Purple Mountain Observatory, Chinese Academy of Sciences

A well-determined radio spectrum for star-forming galaxy (SFG) is critically important for studies that are based on rest-frame radio power, especially those at high-redshift where k-corrections are generally extrapolated the most. In this talk, I will introduce two of our recently completed projects based on the MeerKAT+VLA+ GMRT data in the COSMOS field and the LOFAR+GMRT+VLA data in the ELAIS-N1 field. The MeerKAT data we used are from the MIGHTEE (MeerKAT International GHz Tiered Extragalactic Exploration) project. I will present our measured radio spectral indices between the observer-frame frequencies of 150-400, 400-610, 400-1300MHz, 1.3-3GHz, and 610-5000MHz and show the correlations between radio spectrum and physical properties of radio-selected SFGs. With these results, I will discuss the possible physical mechanisms that determine the radio spectrum of SFGs. I will also show how the adoption of these different radio spectral indices (from low- and high-frequency) in k-correction affects the study of far-infrared-radio correlation of SFGs.

MeerKAT's Sensitivity helps rediscover the Binary Pulsar M30B After Two Decades

Vishnu Balakrishnan

Max Planck Institute for Radio Astronomy (MPIfR)

In a testament to the unmatched sensitivity of the MeerKAT telescope, we have successfully re-detected PSR J2140-2311B, a 13 ms pulsar that had been missing since its discovery in 2001. This pulsar, initially discovered in the core-collapsed globular cluster M30, was suspected to be in a highly eccentric binary orbit. Its elusive nature had left its exact orbital parameters unknown for over two decades.

Using the UHF receivers of the MeerKAT as part of the TRAPUM (TRAnsients and PUlsars with MeerKAT) Large Survey Project, and harnessing the advanced beamforming capability of our backends, we precisely localised the pulsar 1.2(1)' from the cluster center. This study conclusively determined its orbital characteristics, showcasing a very high eccentricity (e = 0.879) and a 6.2-day orbital period. We also measured the rate of periastron advance, $\omega = 0.078 \pm 0.002$ deg yr^{-1}. Assuming that this effect is fully relativistic, general relativity provides an estimate of the total mass of the system, $M_{\rm tot} = 2.53 \pm 0.08 M_0$ consistent with the lightest double neutron star systems known. The formation of M30B likely stemmed from a secondary exchange encounter.

In this talk, I will present a concise overview of these groundbreaking findings from our publication. Furthermore, I'll provide the latest updates from our ongoing timing observations, post-publication, shedding more light on this intriguing binary pulsar. In addition, I will present recent findings from the NGC 6397 cluster, offering more insights into the unparalleled observations MeerKAT provides.

Galactic transient discoveries of the MeerTRAP commensal survey

Mechiel Bezuidenhout
North West University

The more Transients and Pulsars (MeerTRAP) survey has been carrying out a commensal MeerKAT survey continuously for over four years. In that time, we have amassed thousands of hours observing with the FBFUSE beamformer as well as our custom back-end, TUSE, performing a search for transient single pulses in real time. This has led to the discovery of over 100 new fast radio transient sources such as pulsars, RRATs, magnetars, and extragalactic FRBs.

In this talk, I will outline our discoveries of sources within the Galaxy, amounting to about two new transients per month of observing. I will also describe the results of ongoing follow-up efforts of these sources using various telescopes. Finally, I will showcase some of our most notable discoveries, such as the exceptionally intermittent PSR J1710-3452, as well as the renowned 76-second pulsar, J1901-4046.

HI stacking predictions for upcoming surveys with SKA precursors

Sauraj Bharti
IISER Mohali, India

We present our Monte-Carlo simulation of galaxy properties: optical and HI. We use this simulation to study the expected number of direct detections in upcoming surveys (MIGHTEE with MeerKAT and WALLABY with ASKAP). We also study the expected detections in redshifted 21cm line emission with HI stacking. We propose that with these surveys HI stacking can be done in bins with a given range of optical luminosity and color, enabling studies of galaxy evolution in the upcoming surveys. We also discuss the sensitivity of these surveys towards the HI mass function and its evolution with redshift.

Doubling the pulsar population in the Small Magellanic Cloud with MeerKAT

Emma Carli

Jodrell Bank Centre for Astrophysics, University of Manchester, United Kingdom

The Large Survey Project TRAPUM (TRAnsients and PUlsars with MeerKAT) has surveyed the Small Magellanic Cloud (SMC) to search for very rare extragalactic pulsars. Using powerful backends to exploit MeerKAT's groundbreaking sensitivity and implement innovative observing and processing techniques, the survey has doubled the population of pulsars in the SMC and increased the total extragalactic population by 25%.

The discoveries include a young, fast pulsar association in the Pulsar Wind Nebula of one of our targeted sources, the Supernova Remnant DEM S5. Moreover, we discovered another young energetic pulsar and its Pulsar Wind Nebula. Since only a handful of these exotic pulsar environments are known outside our galaxy, this discovery provides a unique opportunity to better understand them. These pulsars have both already exhibited one of the largest known Vela-like "glitches" – extreme starquake events. We have observed a third glitch in another, somewhat older discovery, meaning that nearly half of our pulsar discoveries are young and glitching.

Our discoveries can reveal valuable information on neutron star formation, gravitational wave sources and Fast Radio Bursts, by allowing us to examine the effects of another galaxy's properties onto a neutron star population.

Large-scale jets from black hole X-ray binaries

Francesco Carotenuto

University of Oxford

Black hole X-ray binaries (BH XRBs) can launch powerful outflows in the form of radio-emitting discrete jets, which are generally observed to be produced during bright outburst phases and to propagate up to parsec scales at relativistic speeds. However, little is known about the energy content, the powering mechanism or the composition of these jets, and studying them is also important for estimating the relevant feedback of BH XRBs on the surrounding environment. In this context, MeerKAT observations performed as part of the ThunderKAT LSP in the last 5 years have literally changed the game in the field, allowing us to detect a large number of new jets from these sources and to closely follow their evolution with our monitoring strategy. Thanks to the MeerKAT exceptional sensitivity and imaging capabilities at low (GHz) frequencies, the ejecta could be tracked all the way from launch to their point of deceleration in the interstellar medium, often through months or years of motion. In this talk, I will show how monitoring these objects with MeerKAT has a high potential, as it allows us to model their dynamics and emission with great accuracy and, hence, to constrain their physical parameters. In the specific, I will show how, by applying models derived from gamma-ray burst physics to

BH XRB jets, it is possible to obtain fundamental constraints on the jet kinetic energy, Lorentz factor, inclination angle and ejection date, as well as on the source environment. Overall, our results provide new insights into the physics of jets from BH XRBs and highlight the impact that MeerKAT observations are having in the field of accreting compact objects.

The TRAPUM Survey for New Gamma-ray Pulsars

Colin Clark

Max Planck Institute for Gravitational Physics (Albert Einstein Institute)

One major goal of the TRAPUM Large Survey Project is to use MeerKAT to discover new millisecond pulsars by targeting unidentified GeV gamma-ray sources detected by the Fermi Large Area Telescope (LAT). This sub-project has now discovered more than 30 new pulsars through short, repeated observations of around 150 Fermi-LAT sources. In this talk, I will describe our ongoing survey, and present highlights from among these new discoveries, many of which are in exotic, short-period "spider" binaries, whose discovery rate has been significantly boosted by MeerKAT's exceptional sensitivity. MeerKAT's unique capabilities provide us with sub-arcsecond localisations for our new discoveries, enabling rapid identification of multi-wavelength counterparts to follow up, and easing the process of obtaining full timing solutions and detecting gamma-ray pulsations. I will explain how this allows us to maximise the scientific potential of our new discoveries, with goals ranging from constraining the neutron star equation-of-state with new pulsar-mass measurements, to providing new sources for pulsar timing array projects, and even searching for continuous gravitational waves from our new pulsars in archival detector data.

MPIfR-MeerKAT Galactic Plane Survey (MMGPS) II: science from binary discoveries and the eccentric double neutron star system PSR J1208-5936

Miquel Colom i Bernadich

Max-Planck-Institut für Radioastronomie (MPIfR)

The MMGPS survey at L-band has discovered 16 pulsars in binary systems at the Galactic plane. With data from dedicated follow-ups using the MeerKAT and Parkes telescopes, we measure their orbital parameters and constrain the masses of their companions, unveiling a wide range of astrophysical natures. These consist of a diverse collection of pulsar-white dwarf (WD) systems with different evolutionary histories (including two rare pulsars with light CO-WD companions and one faint pulsar with a massive WD companion) and two eccentric double neutron star (NS) systems. We present these discoveries and their science cases, with a particular focus on PSR J1208-5936, a 28.71-ms recycled pulsar in a double NS system with an orbital period of 15.16 hours and an orbital eccentricity of 0.35. Through timing

with MeerKAT, we constrain the component masses to M_{pulsar}=1.26(+0.13-0.25) solar masses and $M_{companion}$=1.32(+0.25-0.13) solar masses. This system will merge in 7.2 Gyr due to the emission of gravitational waves, rendering it one of the few known precursors of the NS merger events seen by LIGO and Virgo, such as GW170817. Utilizing the new information provided by this discovery and the updated sky coverage offered by the sensitivity of the MMGPS, we update and constrain the NS merger rate based on known Galactic binaries to 293(+222-103) Gpc^{-3} yr^{-1}. Additionally, we predict the detection of 8(+10-4) merger events during the LIGO-Virgo-Kargra O4 run at the 90% confidence level.

High-redshift radio galaxy searches with the MeerKAT Galaxy Cluster Legacy Survey

Vasco Cossa

Rhodes University

I will present the results of my Masters project to comprehensively search for high-redshift radio galaxies (HzRGs) within 20 fields of the MeerKAT Galaxy Cluster Legacy Survey's first data release. These fields stand out due to their robust dynamic range and all-encompassing coverage across the optical and infrared spectrum through the Dark Energy Camera Legacy Survey and the All-sky Wide Infrared Survey Explorer surveys. HzRGs, potentially precursors to local elliptical galaxies, offer a unique lens for exploring diverse astrophysical phenomena, including large-scale cosmic structures, galaxy evolution, and the epoch of reionization. Leveraging adept multiwavelength cross-matching techniques, the candidate pool has been meticulously refined, further bolstered by harnessing in-band spectral indices derived from MeerKAT data. MeerKAT's extreme sensitivity has allowed us to detect a large number of new HzRG candidates, at radio luminosities an order of magnitude lower than other studies, effectively positioning them for subsequent spectroscopic analysis.

Probing for radio and optical diffuse gas in MHONGOOSE galaxy UGCA 250

Mikhail de Villiers

SAAO

MHONGOOSE is an HI Nearby Galaxies Legacy Survey of MeerKAT probing the HI in and around local disk galaxies with an unprecedented combination of high spatial resolution and sensitivity. It will deepen our understanding of the relation between gas and star formation, the baryon cycle, as well as the relation between the distribution of dark and baryonic matter within these galaxies. UGCA 250 is an edge-on, late-type spiral (Sd) galaxy part of this survey. We are conducting a study in which we look for signatures of extraplanar gas associated with this galaxy with the aims of characterising the kinematics of the disk as well as its extensive gaseous

layers. This is achieved due to the ability of MeerKAT to probe the innermost regions as well as the most extended regions associated with this galaxy. We are performing kinematic analysis on the full depth MHONGOOSE radio cubes using tilted-ring modelling and Gaussian decomposition . This is supplemented with high-resolution RSS longslit data from SALT, allowing for the detection of extraplanar gas in both its neutral and ionised states. We find interesting kinematics in both the optical and radio, hinting that the kinematics should be explained by more than a simple disk model. The end result is a multi-wavelength characterisation of the gas associated with this galaxy. Thus, we probe for multi-phase planar and extraplanar diffuse gas associated with this galaxy. This work illustrates how sensitive HI observations with MeerKAT can be combined with high-resolution spectroscopic SALT data to achieve a complete kinematic study of a nearby galaxy.

Cosmic dance in the cluster complex A3528-A3532 in the Shapley Concentration Core

Gabriella Di Gennaro
Hamburg Observatory

Superclusters are the perfect environments where to study galaxy clusters and groups at different stages of their dynamical activity. Particularly, the Shapley Supercluster is richest and most massive concentration of galaxy clusters known to date, and it presents a large variety of radio sources, from radio bridges to radio galaxies.

Here, I will present the newest high-fidelity images of the cluster complex A3528-A3532 in the Shapley Concentration Core, through uGMRT band 3 to 5 and MeerKAT L-band observations. The impressive resolution and sensitivity of the two facilities have revealed for the first time the presence of radio-emitting filaments and bubbles around the brightest cluster galaxies (BCGs), as well as diffuse radio emission on the few hundred kpc scale (e.g. mini-halos). These observations, therefore, provide new insights on the role of cluster minor-mergers on the mechanisms of particle (re-)acceleration, the impact on the radio galaxy activity and the interplay with the surrounding intracluster medium.

Identification of Herschel sources using MeerKAT

Yifan Ding
Imperial College London

High-redshift protoclusters consisting of dusty starbursts has been found to play an important role in galaxy evolution and cluster formation. Their dusty nature makes them difficult to discover in optical/NIR surveys, thus methods utilising Planck and Herschel FIR/submm data to search for them have been developed. However, the large beamsizes of FIR/submm data bring difficulties in determining the exact locations of these dusty galaxies for optical/NIR identification. Radio observations are an excellent way to obtain precise positions of dusty starbursts, as dust is transparent to radio emission and there is a known correlation between the FIR and radio emission of a galaxy. We present MeerKAT 1.28GHz radio imaging of 3 candidate protoclusters selected from Herschel & Planck data. We match our 1.28GHz sources to the H-ATLAS DR2 catalogues using a 7.5″ matching radius giving ∼95% of Herschel sources in the fields a 1.28GHz counterpart. We investigate the FIR-radio correlation by calculating the monochromatic q250μm, which is found to be 2.33 ± 0.26. The Herschel SPIRE colours of our sources indicate that most have redshifts 2-3. We also explore the multiplicity of Herschel sources in our 1.28GHz observations. The 250μm flux distributions of Herschel sources with and without multiple MeerKAT counterparts are found to be statistically different. Lastly, we demonstrate that accurate positions of Herschel sources obtained by MeerKAT observations will allow the cross-identification of these Herschel sources in optical/NIR data.

MeerKAT to Mass Constraints: Optical Modelling of PSR J1910-5320

Oliver Dodge
University of Manchester

PSR J1910-5320 is a new millisecond pulsar discovered during the TRAPUM large survey project's survey of unidentified gamma-ray sources. The precise localisation obtained from the initial MeerKAT detection was found to be coincident with a new candidate redback binary system, independently discovered through its optical variability in the Catalina Sky Survey (CSS) catalogue, and confirmed via optical spectroscopy. Folding the CSS optical photometry with an initial MeerKAT timing ephemeris confirmed the association, revealing a typical spider pulsar light curve, with an optically bright companion being strongly irradiated by the newly-discovered millisecond pulsar. Spider binaries like PSR J1910-5320 are often seen to contain massive neutron stars, and so new spider mass measurements can provide important constraints on the neutron-star equation-of-state. These mass measurements are obtained by solving the binary mass function using estimates of three key parameters. The first, the orbital inclination angle, can be estimated from modelling of optical light curves, for which we obtained new multi-colour observations with ULTRACAM on ESO's New Technology Telescope. The second key, the companion's velocity, is

found through optical spectroscopy. The MeerKAT timing solution provides the final puzzle piece - the pulsar's radial velocity, which constrains the binary mass ratio. I will describe new modifications to the Icarus binary light curve synthesis code that allow us to provide a general optical model for spider binaries, drawing from photometry and spectroscopy simultaneously and self-consistently, and explain how this process leads to a moderate neutron star mass estimate for PSR J1910-5320, and to refined assumptions about the irradiation and atmosphere in redback companion stars.

MKT J170456.2-482100: the first transient discovered by MeerKAT (and other discoveries)

Laura Driessen
The University of Sydney

I will present the discovery and investigation of the binary stellar system MKT J170456.2-482100, the first transient discovered by MeerKAT and the first source to receive the official IAU "MKT" designation. MKT J170456.2-482100 was discovered in the first weeks of ThunderKAT monitoring of the low-mass X-ray binary GX339-4, a field that the ThunderKAT planned to observe every week for the full 5 years of the project. We performed an in-depth archival search and found over 18 years of observations of the source. We used the Southern African Large Telescope to find that the source is a K-type sub-giant with an unknown companion. After two years of weekly monitoring of the GX339-4 field we also found 21 new long-term variable sources. These results in just one MeerKAT field demonstrate the power of the instrument for untargeted searches for variable and transient radio sources, indicating even more exciting results to come. In this talk I will share how we searched for and found MKT J170456.2-482100 and how we investigated the source using both the MeerKAT observations and multi-wavelength observations. I will also present the systematic search for variable sources in the GX339-4 field and the lessons we learned along the way.

A Multi-wavelength Study of the Galactic Point Sources in the MeerKAT Galactic Plane Survey with Gaia DR3

Okwudili Daniel Egbo
UCT/SAAO

The MeerKAT Galactic Plane Survey is a radio continuum survey conducted in the L band ($\sim$1.4 GHz) in the Galactic plane, covering a wide range of galactic longitudes, spanning from 0 to 60 degrees and 250 to 360 degrees and mostly within a latitude range of $|b| \leq 1.5$ degrees. The survey resulted in the detection of approximately 5×10^5 sources. In this study, we present our analysis of the Galactic sources by cross-matching the radio point sources with the Gaia Data Release 3 (DR3) catalog using a Bayesian cross-match approach. To refine our sample and mitigate spurious

and extragalactic counterparts, we imposed a selection criterion based on GAIA parallax over error, focusing on sources with a parallax measurement accuracy of at least 10. This restriction reduced our initial association sample size to approximately 3000 sources. Leveraging the Gaia extinction measurements along the line of sight and the reddening parameter, we applied extinction corrections to the magnitudes and dereddened the colors of the selected sources. Utilizing the dereddened colors and extinction-corrected magnitudes, we constructed a color-magnitude diagram (CMD). The CMD analysis revealed a diverse population of stellar objects, ranging from massive OB stars, white dwarfs, RS CVn binaries, high-mass X-ray binaries (HMXB), YSOs and dMe flare stars. Additionally, we conducted spectroscopic observations of some of the young stars using the Mokodi instrument on the 1-m Lesedi telescope at SAAO. These observations revealed the presence of H-alpha emission, a characteristic emission associated with coronally and chromospherically active radio stars. Our findings provide valuable insights into the radio stellar populations within the Galactic plane, showcasing the diverse range of stellar objects detected in the MeerKAT Galactic Plane Survey. This study highlights the power of cross-matching radio surveys with multi-wavelength datasets, enabling comprehensive characterisation of Galactic sources and advancing our understanding of stellar evolution in our galaxy.

Meet the 49ers: A serendipitous discovery of HI-rich galaxy groups with MeerKAT and the importance of searching Open Time datasets

Marcin Glowacki
Curtin University

Galaxy groups occupy up to 50% of the local Universe and are important parts of the hierarchical structure of the Universe. I report on the serendipitous discovery of 49 HI-rich galaxies in a short Open Time observation with MeerKAT, which make up multiple galaxy groups that were previously unknown. I present their properties such as their HI and stellar masses, and examples of galaxy interactions in the sample. This finding highlights the capability of MeerKAT for other serendipitous discoveries in a remarkably short amount of observing time, and the potential for many more such findings on existing Open Time datasets.

Transients in simultaneous optical-radio data

Kira Hanmer
University of Cape Town

MeerLICHT has been synced to MeerKAT since September 2022, with a total of 53 hours of synced data as of 9 August 2023. Our main aim is to simultaneously identify a possible optical counterpart to a Fast Radio Burst. 78 optical transients have been identified in the MeerLICHT data up until April 2023. I will present these optical transients. The next step in our research is to investigate the simultaneous radio data for these transients.

Cataloguing Compact Sources in MERGHERS Pilot Fields

Brenda Homera
North-West University (Potchefstroom)

The MeerKAT Exploration of Relics, Giant Halos, and Extragalactic Radio Sources (MERGHERS) targets galaxy clusters over a wide range of mass and redshift with relatively short (∼1-2 hr) integration times. MERGHERS's main science goal concerns studies of diffuse radio emission within the clusters themselves. However, given MeerKAT's brightness sensitivity and sensitivity to a large range of spatial scales, a single pointing can be exploited for a wide variety of science questions. To facilitate greater scientific exploitation of the MeerKAT data, we have generated robust source catalogues with high purity and completeness from the full fields of view of the initial MERGHERS pilot targets. In this talk I will present science results, specifically star formation rate studies of MERGHERS cluster and field galaxies, using our generated catalogues which have a combined number of more than eight thousand sources.

New gravity tests with the Double Pulsar in the era of MeerKAT

Huanchen Hu
Max Planck Institute for Radio Astronomy

The MeerKAT telescope opens a new era of high precision pulsar timing in the Southern sky. This brings the accuracy of gravity tests with the Double Pulsar J0737-3039A/B to an unprecedented level and enables precision tests of next-to-leading order (NLO) effects in the orbital motion and signal propagation. In this talk, I will present the latest timing results of PSR J0737-3039A based on MeerKAT observations, including an independent confirmation of the NLO signal propagation effects that are not accessible in any other pulsar systems, namely the retardation effect due to the movement of pulsar B and the deflection of the signal of A by the gravitational field of B. With only 3 years of MeerKAT data, we obtained improved measurements on the Shapiro delay and NLO signal propagation effects. Moreover,

ongoing observations with MeerKAT and in future the SKA are expected to provide one of the first measurements of the moment of inertia of a neutron star, thus providing important complementary constraints on the equation of state at supranuclear densities.

Searching for pulsars and fast radio bursts in the Sculptor galaxy with MeerKAT

Heinrich Hurter
North-West University

The majority of the radio pulsar population were discovered within our own Milky Way Galaxy and its globular clusters, accounting for 99% of all known pulsars. Searching for extragalactic pulsars is thus motivated as it enables us to explore novel star formation histories, pulsar environments, as well as the properties and their dependence on their host galaxy's characteristics. This project was undertaken as part of the TRAPUM Survey, which aims to discover new pulsars and transient events using the MeerKAT radio telescope. Source selection criteria such as a high star formation rate, preponderance of O/B-type stars, galactic mass, distance, and a high number of host supernova remnants led us to choose the Sculptor galaxy for our study. We have not found any radio pulsar or transient within this galaxy and we place a single-pulse flux upper limit of 6.8 micro Jy. Future work will include searches for pulsars and transients in the Large Magellanic Cloud.

Understanding the role of gas-phase transition, turbulence, and magnetic field in star formation

Roger Ianjamasimanana
Instituto de Astrofisica de Andalucia

Many studies of star formation using the HI emission have overlooked the existence of two thermodynamic phases of the neutral atomic hydrogen gas (HI): the Cold Neutral Medium (CNM) and the Warm Neutral Medium (WNM). They treated the HI as one component due to the lack of spectral resolution and signal-to-noise ratio (S/N). With MeerKAT, we have been able to obtain high spectral (0.7 km/s), and high spatial ($<$ 100pc) mosaic HI observations of two (spiral and dwarf) galaxies, NGC 300, and NGC 6822. They have been selected because of their morphologies and proximity to us in order to achieve high spatial resolution. In addition, they have multi-wavelengths data available. Our new MeerKAT data enables us to disentangle the CNM and WNM components, and compare their distribution with different turbulence and star formation tracers (e.g., spectral moments, mach numbers) to understand star formation mechanisms in our targets. We achieved both the S/N and the spectral resolution to treat the HI as two components and make detailed studies of these phases across different features in the galaxies (inter-arms vs spiral arms, inner disk vs outer disk, etc.). As a future prospect, we aim to understand the effects of the magnetic field properties of our targets and correlate them with the observed star formation properties.

Sample properties and implications from the MeerTRAP FRBs discovered with MeerKAT

Fabian Jankowski
CNRS & Université d'Orléans

Fast radio bursts (FRBs) are incredibly luminous radio transients of micro to millisecond duration originating from cosmological distances. Despite rapid progress over the last 15 years and several hundreds of FRB discoveries, their physical origins remain a mystery. Moreover, they are potent probes for ionised media along their lines of sight and cosmology. Since late 2019, our MeerTRAP team has used the FBFUSE beam-former and the TUSE real-time detection system to conduct a fully commensal FRB survey with MeerKAT. In my talk, I will present the FRB samples discovered so far, amounting to more than two dozen new FRBs. In particular, I will focus on their sample properties, such as their observed burst morphologies, scattering and scintillation parameters and what they tell us about intervening ionised media. I will then discuss the characteristics of the MeerTRAP coherent and incoherent beam surveys and what they imply for the FRB all-sky rates, repetition parameters, the underlying FRB populations, and, eventually, cosmology.

First MeerKAT Observations of the Brightest M31-M33 HI Cloud in the Circumgalactic Medium of M31

Kyra Kummer
Department of Astronomy, University of Cape Town

In 2004, Braun and Thilker discovered a bridge of extremely faint, diffuse HI gas connecting the galaxies M31 and M33. Follow-up, higher resolution observations by Wolfe et al. (2013, 2016) with the Green Bank Telescope (GBT) revealed that the filament broke up into higher column density clouds, with a total of nine individual and discrete clouds of HI discovered in the region surveyed. The nature of these clouds remains an open question. Potential origins of the clouds are speculated to include, the products of galaxy interactions, dwarf galaxies, high velocity clouds, dark matter sub-halos, gas in planes of satellites, a dark matter filament, or condensations of the circumgalactic medium of M31. The previous observations lacked the spatial and spectral resolution to probe the internal structure of the clouds in order to probe their nature, effectively limiting our understanding of these objects. We present the first MeerKAT observations of the brightest cloud in the filament. Our initial analysis has made it clear that the superior spatial and spectral resolution of the MeerKAT observations reveal that the cloud has a more complex small-scale internal kinematic structure than anticipated. We will discuss how this HI cloud compares to those clouds seen around the Milky Way and the implications for its potential origins.

Hunting dark matter with MeerKAT

Natasha Lavis
University of the Witwatersrand

The nature of dark matter remains a gap within our current cosmological paradigm, but MeerKAT may hold the key to helping us reveal this occult substance. Historically radio-frequency indirect dark matter detection has been avoided due to the complication of characterizing magnetic field environments. With the advanced capabilities of the new generation of interferometers, radio detection may prove to be a robust way to examine the alleged signals of dark matter annihilation. The potential of MeerKAT, currently the world's best interferometer, as a dark matter search engine has been only minimally investigated. Galaxy clusters prove to be robust labs for radio dark matter detection, as they are known to host large-scale diffuse emission, are dark matter dominated, and contain large-scale magnetic fields. MeerKAT Galaxy Cluster Legacy Survey (MGCLS) provides an abundance of target environments. We use the wealth of data available to investigate dark matter emission in a sample of clusters. Through an integrated flux comparison of predicted signals to those observed, we have produced competitive upper limits on the annihilation cross-section, where under the assumption of a thermal relic population weakly interacting massive particles (WIMPs) have been excluded for masses less than 800 GeV in the galaxy cluster Abell 4038. It is expected that targets in which no halo-like diffuse emission is observed may further improve on these results, by limiting the maximum allowed signal from dark matter to the faintest emission observable by MeerKAT. I will present the results of our investigation on a set of massive clusters where no diffuse emission has been detected.

A serendipitous MeerKAT discovery of an HI-rich galaxy group with megaparsec-scale filamentary-like structure

Graham Lawrie
University of the Witwatersrand

Environmental effects within cosmological overdensities like galaxy groups and clusters have been shown to impact galaxies and their gas reservoirs. This makes the study of a wide range of environments important in order to discern between different models of galaxy evolution. This presentation will report the serendipitous discovery and properties of a large overdensity of HI galaxies at $z \sim 0.04$. The galaxies appear to lie in a filamentary-like structure of Mpc scale. Dark Energy Survey (DES) DR2, and Wide-field Infrared Survey Explorer (WISE) data are used to investigate the star formation rates, stellar masses, and stellar morphologies enabling individual galaxy analysis and comparison of this structure's properties with established scaling relations. The HI and sub-arcsec DES imaging reveal a large number of interacting galaxies in this collective group. To place this discovery and the environmental effects in context, we use a state-of-the-art cosmological hydrodynamical simulation, SIMBA, to construct light cones and investigate the prevalence of HI overdensities and their large-scale morphological properties. This enables a

prediction on how many more such structures might be discovered with MeerKAT to provide a rich sample to study galaxy transformation and enable a MeerKAT HI perspective on low-redshift large-scale structure.

Exploring the Ophiuchus cluster with MeerKAT Galactic Plane Survey

Austin Louw

The Ophiuchus cluster is one of the brightest X-Ray clusters in the Local Universe. Part of the Ophiuchus cluster extends into the Zone of avoidance, making the fraction of the cluster that coincides with the Zone of Avoidance (ZoA) difficult to observe in optical and Infrared wavelengths. The reason for this is because of the obscured dust and thick stellar emission caused by the Milky Way. In this project, we use the HI 21-cm emission observations that were taken as part of the MeerKAT Galactic Plane Survey (MKT-GPS) to study the large-scale distribution of galaxies in the Zone of Avoidance over the Galactic longitude range $-30^\circ < l < 55^\circ$ and Galactic latitude range $-1.5^\circ < b < 1.5^\circ$). We will be looking at galaxies with a redshift velocity from 7500 km s^{-1} up to 23000 km s^{-1}. We will also be looking for any connection between the Great Attractor and the Ophiuchus cluster when exploring the distribution of galaxies in the Zone of Avoidance.

The MeerTime Thousand Pulsar Array: Elucidating the population properties of neutron stars

Marcus Lower (on behalf of the TPA)
CSIRO/ATNF

The long-term timing of radio pulsars yields a rich vein of science. The Thousand Pulsar Array (TPA) programme uses the power of MeerKAT in sub-array mode to monitor and time more than 500 pulsars with a monthly cadence. This allows us to explore the turbulent, magnetic structure of the interstellar medium through the time-variability of the dispersion and rotation measures. More importantly it sheds light on the spin-down history of these pulsars and the correlation between changes in the torque and observed radio profile shapes. Understanding this behaviour is a critical component in the detection of gravitational waves through pulsar timing arrays. In this talk I will introduce the TPA long-term monitoring programme, provide an overview of the current project status and describe key science results, including measurements of pulsar viewing and magnetic geometries, assessing the stability of pulsar spin-down rates with time, and an observationally driven unification of the bulk properties of young and millisecond pulsars.

Searching for HI-rich UDGs and LSBs in the Hydra I Galaxy Cluster

Nazir Makda
South African Astronomical Observatory

Ultra-diffuse Galaxies (UDGs) are low surface brightness galaxies with a very low stellar mass component, however, their sizes are comparable to the Milky Way. They are predominantly found in clusters even though they would be expected to be cannibalised by the strong tidal fields in clusters. The broad range of observed characteristics of UDGs suggest several formation mechanisms influence their evolution, including both internal processes like star formation outflows and external environmental processes such as tidal and ram-pressure stripping interactions. Neutral atomic hydrogen, HI, is the best tracer of gas removal and quenching, and likely the key to uncover the formation and evolution of UDGs. The detection and analysis of the HI can provide constraints on the redshift (i.e. cluster membership) of UDGs - extremely difficult to measure using optical spectroscopy due to the faintness of these objects - and enables the study of the effects of tidal and ram-pressure mechanisms on UDGs in the cluster environment.

We used MeerKAT to obtain HI data for galaxies in the centre of the Hydra I galaxy cluster, following up on UDGs and LSBs identified in an optical catalogue (Iodice et al. 2020, La Marca et al. 2022). In this talk, I will discuss the detection and characterisation of these galaxies in HI, and present their redshifts, confirming that they are associated with the cluster and constraints on their HI masses.

MeerLIRGs: A MeerKAT 1.28 GHz study of local Luminous Infrared galaxies in the southern hemisphere

Malebo Moloko
University of Cape Town

Luminous Infrared galaxies (LIRGs) are rare in the local universe but play a crucial role in our understanding of galaxy evolution, as they account for over 50% of the cosmic-infrared background and most of the stars formed at $z > 1$. They are often associated with interacting and merging systems, whose complexity requires high spatial imaging to disentangle Star Formation (SF) and any Active Galactic Nuclei (AGN) that may be hidden in their dusty shrouds. Infrared Astronomical Satellite (IRAS; Neugebauer 1984) observations revealed the existence of numerous galaxies that emit the bulk of their energy in the infrared regime, with LIRGs being one of the most powerful ($L_{ir} > 1011 L_{\odot}$) populations. There is a tight correlation observed between the infrared and radio continuum of star-forming galaxies which makes the MeerKAT L-band observations an excellent complimentary tracer of SF and delineator of AGN. In this work, we study the properties of 298 galaxies with $S > 5.24$ Jy selected from the IRAS Revised Bright Galaxy Sample (RBGS; Sanders 2003) located in the southern hemisphere, observed with MeerKAT at 1.28 GHz using the L-band; dubbed as the "MeerLIRGs". The MeerKAT snapshots have a 7.5″ FHWM

resolution and sensitivity of $\sigma \approx 20\mu$Jy/beam. We obtain the activity type classification from the literature and classify them based on their mid-infrared WISE colours; then study their properties. We further compare our results with those of galaxies drawn from the same sample but observed with the VLA (by Condon (1990, 1996 and 1998) and are located in the northern hemisphere. A combination of this MeerKAT data and the above-mentioned VLA catalogues encompass the full radio catalogue of the RBGS sample. Thus in my contribution, I will present this sample's Infrared and radio correlation, the global properties of our galaxies and the entire associated radio catalogue of the RBGS.

Extended halos around UC HII regions in the MeerKAT GPS

Mubela Mutale

University of Leeds

The ultracompact (UC) HII region phase of a massive star overlaps significantly with its main-sequence lifetime, therefore playing an important role in improving our understanding of the birth of massive stars. The lifetime of an UC HII region is estimated to be of the order 10^4 years. However, previous studies have shown that the number of UC HII regions is inconsistent with their estimated lifetime. HII regions expand with time, thus their lifetimes scale directly with their size. Studies carried out on samples subject to selection biases have estimated that 80% of UC HII regions have underestimated sizes, implying a longer lifetime than 10^4 years. In this talk, I will present a large unbiased sample of HII regions drawn from the MeerKAT Galactic Plane Survey (MeerKAT GPS). In this unbiased sample, I find that roughly a third of the UC HII regions have underestimated sizes. Therefore, while this implies a longer lifespan than the dynamical age of an UC HII region, it only provides a partial solution to the problem.

RAM PRESSURE STRIPPING OF NEARBY DWARF GALAXIES FOR TESTING THEIR MASS

Brenda Namumba

Wits University

The discovery by MeerKAT that WLM, an isolated dwarf galaxy, is ram-pressurized raises fundamental questions about the dwarf galaxy interplay with the Inter-Galactic Medium (IGM). In order to study for the first time the possibility of ram pressure in dwarf galaxies, we present low-brightness MeerKAT HI emission maps around 4 dwarf galaxies at much higher sensitivity and resolution compared to the literature. This study will allow us to robustly establish the exact role of the IGM on dwarf galaxy evolution.

Improving timing solutions of TRAPUM pulsars with joint radio and gamma-ray analyses

Lars Nieder
Max Planck Institute for Gravitational Physics (AEI Hannover) / Leibniz Universität Hannover

MeerKAT searches of unidentified Fermi-LAT gamma-ray sources by the TRAPUM large survey project have discovered more than 30 new millisecond pulsars. A radio follow-up timing campaign using MeerKAT, and augmented with observations from other radio telescopes, has enabled the detection of gamma-ray pulsations from 12 of these. The two types of data are very different in some aspects. For example, the radio data provides extremely precise pulse arrival times, but often has gaps and typically only covers the time span between detection and the most recent observation. The gamma-ray data however is sparse, but covers the full 15 years between the launch of the Fermi satellite and today. Previously, these data sets have been treated separately - radio timing solutions are typically only used as a starting point for gamma-ray timing, with some parameters fixed at their radio values. However, a joint analysis of both the radio and gamma-ray data can provide additional sensitivity and precision beyond that which can be obtained from either data set alone. In this talk, I will present the radio timing campaigns, the gamma-ray follow-up searches, and four TRAPUM pulsars timed jointly in radio and gamma. I will shortly describe the data sets, the timing method and show how the extra precision provided by joint timing enables the detection of proper motion that could not be measured when treating the radio and gamma-ray data separately, leading to better constraints on the energetics of the newly-discovered millisecond pulsars.

The census of the non-recycled radio pulsar population with MeerKAT - new constraints on the radio emission process from the time-averaged pulse profiles

Bettina Posselt
University of Oxford

The overwhelming majority of the known neutron star population are detected radio pulsars. The physics of the radio emission process and the alteration of the radio emission along the travel path to the observer still pose many open questions. For instance, which radio properties correlate and / or connect with distinct neutron star populations and what is the physical underpinning explanation for this? How do its radio properties change as a pulsar gets older?

Although there is a great number of radio-detected pulsars, only the brightest could be investigated in detail in the past. Our knowledge about radio pulsars was also limited by inhomogeneous observational sensitivity and frequency coverage. The high sensitivity and large frequency bandwidth of the MeerKAT radio telescope enabled the Thousand-Pulsar-Array (TPA) project to gather an unprecedented large homogeneous and comprehensive data set from non-recycled radio pulsars.

I will present our homogeneous TPA measurements, e.g., fluxes, spectral indices, pulse widths, and polarisation fractions from the census of time-averaged pulsar data for more than 1000 pulsars. Highlighting our new statistical constraints on the relations between the measured pulse profile quantities and pulsar properties such as the spin-down energy, I will discuss interpretations with respect to the pulsar radio emission process.

TRAPUM search for radio pulsars in the Large Magellanic Cloud

Venu Prayag
University of Cape Town

The Large Magellanic Cloud (LMC), at 50 kpc away from Earth, is one of our closest galactic neighbours. It has distinctive traits, including a lower metallicity, a higher rate of star formation, a larger abundance of supernova remnants, and a greater presence of high-mass X-ray binaries per unit mass compared to our Milky Way galaxy. Consequently, the LMC serves as an extraordinary astronomical laboratory for studying pulsar populations in an environment different to that of the Milky Way. As part of the TRAPUM project, using MeerKAT, we are conducting targeted searches for extragalactic radio pulsars within the LMC. MeerKAT achieves over 7 times the sensitivity of previous LMC surveys, enabling us to probe deeper than before. The additional sensitivity of MeerKAT has proven its worth and I will be presenting all of our new discoveries, keeping in mind that prior to this study, only 25 pulsars were known in the LMC.

Exploring the uncharted Vela Supercluster: Insights from MeerKAT HI Surveys

Sambatriniaina Rajohnson
University of Cape Town

Our research is dedicated to shedding light on the uncharted territories within the Zone of Avoidance (ZOA), a portion of the sky obscured by our Milky Way's dust and stars. This region is known to partially conceals numerous dynamically important structures in the nearby Universe. Utilizing the 21cm-line emission, HI surveys have proven to be the sole effective method for penetrating this highly obscured region, significantly reducing the ZOA gap. However, previous HI surveys lacked the necessary frequency coverage, sensitivity, and angular resolution to trace the HI-rich galaxy population of the recently discovered Vela Supercluster (VSCL). The VSCL, situated at a distance of $\sim$260 Mpc, remains largely unexplored, despite its potential to help resolve discrepancies in bulk flow measurements. Utilizing the MeerKAT telescope's capabilities, we have embarked on systematic blind HI surveys to reveal the morphology and mass overdensity of the VSCL. Designed to connect known structures near the Galactic Plane with the optically obscured part

of VSCL, the two HI surveys jointly encompass an area of ∼300 square degrees over $\Delta l = 30\,\mathrm{deg}$ and $|b| < 7\,\mathrm{deg}$. I will showcase the distribution of the highly obscured, HI-rich galaxy population out to $cz < 25000$ km/s, revealing indications of two wall-like structures crossing the ZOA at the VSCL distance ($16000 < cz < 23000$ km/s). This will then be followed by an in-depth assessment of the supercluster's overdensity, based on an HI mass function analysis.

Exploring the thickness of galaxy disks in HI

Notahiana Ranaivoharimina
University of Cape Town

Understanding the thicknesses of disk galaxies is crucial since it allows the determination of galaxy properties such as the volumetric star formation law and the shape of dark matter halo. The HI component stands out since neutral hydrogen due to its ubiquity in disk galaxies and its tight connection to star formation and feedback in galaxies. In this project, we will present the results obtained from examining the HI scale heights of four edge-on MHONGOOSE galaxies at z = 0, discuss how they relate to other properties of the galaxies, including the scale height in the IR and optical, and discuss the implications for star formation and feedback in these galaxies.

MeerKAT follow-up of enigmatic radio sources in the G4Jy Sample

Katlego Sejake
University of Pretoria

The GLEAM 4-Jy (G4Jy) Sample, formed from the GLEAM survey, comprises 1,863 of the brightest extragalactic radio-sources in the southern sky, the vast majority of which are active galactic nuclei with powerful radio jets. However, 140 of these sources have uncharacterised/ambiguous host galaxies due to the inadequate resolution (of 25 to 45-arcsec) of existing radio images. In this talk, I present key results from studying these 140 G4Jy sources These sources were observed with MeerKAT to assess their radio morphology and enable their host-galaxy identification through MeerKAT's higher resolution images. Our observations reveal a treasure trove of unusual radio sources: 5 of the 140 G4Jy sources have X-, S-/Z-shaped morphology, 10 have head-tail morphology, and 14 have a wide-angle tail (WAT) morphology. We report finding host galaxies for 98 of the 140 sources, leaving 42 with no identified host galaxy (Sejake et al., 2023).

A survey for redback candidates with MeerKAT

Tinn Thongmeearkom
University of Manchester

Redbacks are binary star systems with a millisecond pulsar and a low-mass irradiated companion. These systems exhibit properties that can be used to study binary evolution, pulsar winds, and make neutron star mass measurements. Throughout the years, many projects have monitored Fermi-LAT gamma-ray unidentified sources across the electromagnetic spectrum. As a result, they have identified some high-confidence redback candidates using optical and X-ray light curves and which currently have no evidence of radio pulsars. Attempting to find radio pulsations from the neutron stars in these systems, we have conducted a deep survey of six redback candidates with MeerKAT at L-band and UHF as part of the Fermi working group of the MeeKAT LSP project called TRAPUM. We will present three new millisecond pulsars that we have discovered. Two of them have extraordinary eclipses. Lastly, we will also present the results of our radio and gamma-ray timing campaigns, which provide orbital parameters for pulsar-mass measurements.

Unveiling large scale structure formation in the nearby Universe. The spectacular case of the Shapley Concentration

Keegan Trehaeven
Rhodes University

The Shapley Supercluster (mean redshift $z = 0.048$) has one of the most extensive collections of galaxy clusters in the local Universe. At its heart lies the Shapley Supercluster Core (SSC), consisting of many clusters and groups at various evolutionary stages of merger activity. The SSC is thus a unique test bed to study mass assembly history and the complex kinematics of large-scale structure formation in the Universe. The entire complex spans $\sim 4^\circ$ on the sky, containing an extremely faint ~ 1 Mpc inter-cluster radio bridge (diffuse synchrotron emission that connects pairs of gravitationally interacting galaxy clusters) and many other intriguing non-thermal diffuse sources that probe the underlying dynamics of this chaotic environment. We aim to compare MeerKAT and uGMRT radio continuum observations and perform the first dedicated spectral study of an intercluster radio bridge to unveil the past and current dynamics of this region and the merger activity of the broader complex. A preliminary integrated spectrum of the bridge between MeerKAT L-band and uGMRT band-3 gives a flatter spectrum than expected, at $\alpha_{0.4\,\mathrm{GHz}}^{1.28\,\mathrm{GHz}} = 1.1 \pm 0.3$ ($S_\nu \propto \nu^{-\alpha}$), suggesting very mild ongoing in-situ particle (re)-acceleration. However, detailing and tracing the merger history with robust spectral index and ageing maps requires ultra-deep continuum images of uniform sensitivity across the entire complex. Hence, we demonstrate, using DDFacet and other radio interferometric data reduction software, a novel technique of visibility-plane primary-beam-corrected mosaicing up to and including direction-dependent calibration. This technique can be extended to large survey projects such as those planned

for the MeerKAT+ and the SKA to, in principle, image the entire radio sky at an unprecedented uniform sensitivity.

Mining Mini-Halos with MeerKAT

Keegan Trehaeven
Rhodes University

Radio mini-halos are clouds of diffuse, low surface brightness synchrotron emission that surround the Brightest Cluster Galaxy (BCG) in massive cool-core galaxy clusters. In the first paper of the series (Trehaeven et al. 2023), we use third generation calibration (3GC), also called direction-dependent (DD) calibration, and point source subtraction on MeerKAT extragalactic continuum data in order to study such sources. We calibrate and image archival MeerKAT L-band observations of a sample of five galaxy clusters. We use the CARACal pipeline for direction-independent (DI) calibration, DDFacet and killMS for 3GC, followed by visibility-plane point source subtraction to image the underlying mini-halo without bias from any embedded sources. Our 3GC process shows a drastic improvement in artefact removal, to the extent that the local noise around severely affected sources was halved and ultimately resulted in a 7% improvement in global image noise. Thereafter, we directly measure for four mini-halos the flux density, radio power, size and in-band integrated spectra. Further to that, we show the in-band spectral index maps of the mini-halo (with point sources). We present a new mini-halo detection hosted by MACS J2140.2-2339. We also found a $\sim$100 kpc southern extension to the ACO 3444 mini-halo which was not detected in previous VLA L-band observations. Our description of MeerKAT wide-field, wide-band data reduction will be instructive for conducting further mini-halo science. In an upcoming follow-up paper, we compare our L-band and newly observed UHF-band data to Chandra X-Ray data to study the relationship between the thermal and non-thermal components of the ICM in an attempt to discriminate between proposed mini-halo production mechanisms. Such investigations include a point-to-point spatial correlation test between the thermal and non-thermal surface brightnesses and a previously untested correlation between mini-halo radio power and the velocity dispersion of the thermal gas.

Searching for Pulsars and Fast Transients in Supernova remnants, Pulsar wind nebulae and unidentified TeV sources

James Turner

Jodrell Bank Centre for Astrophysics, The University of Manchester

Supernova remnants and pulsar wind nebulae are ideal places to hunt for young and energetic pulsars. Targeted pulsar searches of these sources have often been limited due to the difficult balance between efficient telescope use and achieving useful sensitivity. As an interferometer, MeerKAT combined with FBFUSE/APSUSE is able to overcome these trade-offs owing to its fantastic sensitivity, adaptable beamforming capability and a plethora of high-performance hardware and software infrastructure. Deep searches of over 120 Galactic remnants and wind nebulae (including unidentified TeV sources plausibly driven by a pulsar engine) are under way as part of the TRAPUM (TRAnsients and PUlsars with MeerKAT) Large Survey Project. We will report on our discoveries which include; an adolescent pulsar within the candidate composite remnant G22.0+0.0, and a slow pulsar positionally coincident with the shell-type supernova remnant G15.9+0.2. Furthermore, as part of collaborative efforts with ThunderKAT, we helped confirm the newly discovered Mini Mouse to be a bow-shock pulsar wind nebula. We will also discuss how expanding the population of young radio pulsars finds purpose in helping to constrain the Galactic neutron star birthrate, early-age spin evolution and also in improving our understanding of the energy budgets between pulsars and their wind nebulae.

The MeerTime RelBin Programme: Unveiling gravity's mysteries through binary pulsar experiments

Vivek Venkatraman Krishnan

Max Planck Institute for Radio Astronomy

Binary systems with radio pulsars are some of the most useful natural laboratories in space. Even in the era of routine gravitational wave detections from merging neutron stars and black holes, binary pulsar experiments constitute a unique place by providing some of the most definite and complementary constraints for understanding gravity and nuclear physics. They routinely provide precise neutron star mass measurements that constrain their internal composition, contribute to the understanding of binary evolution of degenerate stars, and perform stringent tests of theories of gravity. The importance of binary pulsar experiments are corroborated by the fact that they have been one of the flagship science cases of the Square Kilometer Array telescope. The MeerKAT telescope, as a precursor for the SKA, has already started providing some ground breaking results in this regime as part of the MeerTime Relativistic Binary Timing programme (RelBin). In this talk, I will introduce the RelBin pulsar timing programme, provide an overview of its operations for the last 5 years, and discuss the science results that range from measurements of rare relativistic effects, a slew of new neutron star mass measurements, constraints on peculiar binary evolution scenarios, to tests of GR and scalar-tensor gravity.

Spectral Stacking of deep MeerKAT data: search Neutral Hydrogen Clouds in the Inter-Galactic Medium of the Local Universe

Simone Veronese

ASTRON - Kapteyn Astronomical Institute

The investigation of the large-scale distribution of neutral hydrogen (HI) within the cosmic web is fundamental in comprehending the intricate processes governing galaxy formation and evolution. Evidently, the star formation rate observed throughout cosmic history necessitates galaxies to continually replenish their gas reservoir. Theoretical simulations predict that this replenishment primarily occurs via accretion of pristine gas situated within the Inter Galactic Medium (IGM). Nonetheless, the detection and comprehensive characterization of these HI clouds have proven to be formidable endeavours, due to their faint luminosity, compact nature, and sparse distribution. I will present an innovative approach to search for neutral hydrogen clouds within the IGM. The methodology employs the spectral stacking technique applied to data from the MeerKAT Observations of Nearby Galactic Objects: Observing Southern Emitters (MHONGOOSE) survey, in conjunction with a one-dimensional source finder tool modelled after the established Source Finding Application (SoFiA-2). The outcome is the tentative detection of an excess of gas around some MHONGOOSE galaxies. In the talk I will focus on how to determine the robustness of these detections by systemically analysing the outcomes of spectral stacking on pure Gaussian noise, coupled with results of stacking state-of-art cosmological simulations. The proposed methodology opens a new avenue for investigating low surface brightness gaseous structures, that could be ultra-diffuse galaxies as well as pristine gas reservoirs.

MeerKAT discovery of unique binary pulsars in globular cluster Terzan 5 and a search for compact pulsar binaries using volunteer distributed computing.

Prajwal Voraganti Padmanabh

Max Planck Institute for Gravitational Physics (AEI)

Globular clusters have historically been a prime target for radio pulsar searching owing to their old stellar population and dense environment. The Terzan 5 globular cluster is one such source that houses numerous pulsars and has been extensively studied at multiple wavelengths. In this talk, I will be presenting 9 new binary pulsars discovered in Terzan 5 using MeerKAT as part of the TRAPUM survey. These include a potential double neutron star system with a total mass of 3.2 solar masses and if confirmed, would host the fastest spinning pulsar (P $\sim$ 2.27 ms) for any double neutron star system (DNS) known. Three systems belong to a class of spider pulsars that show radio eclipses due to material from the non-degenerate companion obscuring the pulsed emission. We were also able to precisely measure the individual masses for a system by measuring the Shapiro delay due to the binary

companion. Some discoveries pose open questions regarding their stellar evolution and formation. The total number of confirmed pulsars in Terzan 5 is now 49, the most for any globular cluster. Finally, I will describe Einstein@Home, a volunteer distributed computing project. Through Einstein@Home, we aim to find compact pulsar binary pulsars (30 min $<$ Pb $<$ 300 min) in MeerKAT globular cluster data using coherent template-bank methods. This setup has already demonstrated its capability by blindly redetecting several known pulsars in multiple globular clusters.

Investigating HI Cosmology with MALS images

Anthony Walters
UKZN

While designed to study the evolution of cold gas through their redshifted absorption lines in the L- and UHF- bands, the MeerKAT Absorption Line Survey (MALS) produces data which also contains information on redshifted HI in emission, in some cases, on interesting cosmological scales. These data consist of 391 pointings, each covering a 1.8 deg^2 patch on the sky, from which one can generate numerous high resolution image-cubes. Here we generate such cubes in a 60MHz spectral window, corresponding to HI at $0.4 < z < 0.5$, construct their cylindrically- and spherically-averaged power-spectra, and investigate the possibility of detecting the HI power spectrum via a combined analysis of all the pointings.

HI at unprecedented sensitivities: results from MHONGOOSE galaxy UGCA320 and neighbours

Nikki Zabel
UCT

One of the key questions in the field of galaxy evolution is "How do galaxies assemble and evolve?". As one of the first MeerKAT large programmes, the MeerKAT HI Observations of Nearby Galactic Objects - Observing Southern Emitters (MHONGOOSE) survey aims to address this question by imaging the diffuse gas at the outskirts of galaxies down to column densities as low as $\sim 5 \times 10^{17}$ cm^{-2} for the first time, looking for direct evidence of accretion, among other science goals. In this talk I will show results from one of the MHONGOOSE targets, dwarf galaxy UGCA320, as well as serendipitous HI detections of its neighbours, as is part of a small galaxy group. I will present an analysis of their HI distributions and velocity fields, and discuss their possible interpretations in the context of the group environment.

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