SPARCS XII: Pushing Toward the Final Frontier

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Report of Abstracts

Galactic & AGN/ High-z / 107

A Complete Characterisation of Ultra Steep Spectrum Sources in the COSMOS Field

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Ultra Steep Spectrum (USS) radio sources have been successfully used to select powerful radio galaxies at high redshifts. Typically restricted to large-sky surveys and relatively bright radio flux densities, it has gradually become possible to extend the USS search to new sensitivity levels, thanks to a new generation of radio surveys produced by the so-called SKA-pathfinders. Combining recent observations from MIGHTEE (the MeerKAT International Gigahertz Tiered Extragalactic Explorations) and VLA-COSMOS we identify more than 700 USSs, the majority of which with optical/near-infrared counterparts and redshift estimates. Using the comprehensive multi-wavelength dataset available over this area, we are able to extensively characterize this population, and explore the usefulness and efficiency of the USS radio criteria to reach the highest redshifts at the faintest radio fluxes, of clear relevance to the preparation of future SKA surveys. We find that the faint USS source population doesn't show significant differences from the broader sub-mJy radio population, in particular revealing a large number of star-forming galaxies with a redshift distribution peaking at z<1. In spite of this apparent lack of efficiency of the USS criteria in selecting very high redshift galaxies, at the faintest radio flux levels, sources at very high redshift (z>6) are still found in our sample. This suggests the possibility of exploring compound observational diagnostics to optimize the search for very high redshift radio sources, in particular in the upcoming SKA-era.

keywords:

radio galaxies, AGN, epoch of reonization, high redshift

In-person or online?:

online

Career level:

Student

Techniques / 21

A Pipeline for Detection of Sources from Radio Observation Images Based On Deep Learning Framework

Author: Peng Jia[1]

[1] *Taiyuan University of Technology*

Upcoming radio sky survey projects, such as the Square Kilometer Array (SKA), are anticipated to collect vast amounts of observational data, encompassing the spatial and frequency distribution of various celestial objects. The detection and segmentation of these celestial objects from the observational data are crucial for further scientific investigation. However, directly detecting celestial objects from the observation data poses a challenge, particularly considering the high spatial resolution and multitude of channels involved. In this study, we propose a pipeline designed to detect and segment celestial objects directly from the observation data. The pipeline initially locates the distribution of celestial objects in two spatial coordinates and one frequency coordinate with a modified Faster-RCNN, and subsequently segments the data cube into celestial object distributions using the Gaussian fitting method. We evaluate the effectiveness of our pipeline using both simulated and real observation data, and the results demonstrate the efficacy of our method in directly detecting targets from the observation data.

keywords:

Deep Learning, Neural Network, Imaging

In-person or online?:

unsure

Career level:

ECR

Poster Sparklers / **47**

A combined JVLA and XMM study of the galaxy cluster Abell 795

Author: Nicolò Rotella[None]

I am currently working on my master thesis about the multiwavelength study of the galaxy cluster Abell795. I am using new data from XMM-Newton and JVLA, trying to understand if in the central region a diffuse source is present and the possible link between such radio source and the large-scale dynamics of the intracluster medium.
In fact, as previously found by Ubertosi et al. 2021 from the analysis of Chandra data, in the central region there are evidences of a sloshing motion of the brightest cluster galaxy (BCG), which is surprisingly classified as an FR0 radio galaxy.
The objective of my thesis project is to discern either whether the diffuse radio emission indeed constitutes an erstwhile phase of feedback, subsequently perturbed and reaccelerated by the turbulence of the intracluster medium, or whether it has a different origin.
Since the preliminary results of my new analysis of the XMM data revealed the presence of a nearby group within the vicinity of R200, I am concurrently endeavoring to investigate the potential interaction between this group and the cluster. This investigation aims to shed light on whether such an interaction might be the root cause behind the observed sloshing phenomenon.
Moreover, XMM data showed the presence of a surface brightness excess in the South East region of the cluster, further from the centre with respect to the two cold fronts found by Ubertosi with Chandra data. If this feature is confirmed, it will corroborates the hypothesis of the presence of a sloshing motion by the BCG.

keywords:

clusters, diffuse radio emission, FR0

In-person or online?:

in-person

Career level:

Student

Galactic & AGN/ High-z / 135

A population-based approach to understanding radio AGN feedback with LOFAR-VLBI

Author: Jonny Pierce[1]

[1] *The University of Hertfordshire*

Early results from the LOFAR Two-Metre Sky Survey (LoTSS) revealed that radio AGN are prevalent in local massive galaxies, with all those above a stellar mass of $10^{11} M_{\odot}$ being switched on at radio wavelengths. Inference-based jet modelling for LoTSS radio AGN then showed that the integrated power output of the population is sufficient to counterbalance X-ray radiative cooling losses in groups and clusters in the local Universe, as is required by current models of galaxy evolution. While these results exhibit the feedback potential of the population as a whole, the majority of LoTSS radio AGN were found to be unresolved at the 6”resolution limit of the survey, meaning that marginalisation over the unresolved size distribution was required for the jet power inference and the dominant scales on which the feedback occurs remained uncertain. In this talk, I will describe how we have combined LoTSS and LOFAR long-baseline imaging of the Lockman Hole field at resolutions of 6”, 1” and 0.3” to measure the sizes of 1287 radio AGN and improve our understanding of the size distribution in the radio AGN population. While there are many sources with projected physical sizes of 100 kpc - 1 Mpc, we see that the sample is dominated by galaxy-scale objects, with over half being smaller than 30 kpc in size. We thus find that the uniform lifetime distribution capable of explaining the sizes of large radio sources cannot describe the size distribution of radio AGN across the population, and strong weighting towards shorter lifetimes is needed. I will also show how SED-based classifications for the radio sources refine the separation between AGN and star-forming galaxies, allowing the jet kinetic luminosity function to be investigated out to z ~ 2.5.

keywords:

AGN, imaging, AGN feedback, modelling, jets

In-person or online?:

unsure

Career level:

ECR

Poster Sparklers / 109

A preview of SKA-VLBI: a cosmological application of strong lensing and VLBI

Author: Filippo Malvolti[None]

Co-authors: Cristiana Spingola [1]; Daniele Dallacasa [2]

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[2] *University of Bologna, Astronomy Dept.*

The ΛCDM model shows inconsistencies with observations on galactic and sub-galactic scales that are exemplified by the ”missing satellite problem”. Despite the large number of sub-halos predicted

in the Local Group, only a few galactic satellites have actually been observed. At high redshift *strong gravitational lensing* can probe the presence of these sub-halos by means of their gravitational effect, which is expected to be at milliarcsecond scale. Some specific gravitational systems show deviations from the predictions of a smooth model, called *anomalies*, that are often attributed to the presence of sub-halos.
In this poster we present the analysis of a global-VLBI observation of the strongly lensed jetted AGN JVAS B1555+375. JVAS B1555+375 is a quadruply imaged system with a strong flux ratio anomaly. Recent near-infrared observations revealed an edge-on disc in the lensing galaxy, which crosses directly over the pair of images exhibiting the anomaly. Our milliarcsecond and μJy/beam sensitivity observation detected only three of the four predicted images and revealed, for the first time, the presence of an astrometric anomaly. The baryonic ionized matter of the edge-on disc could be the dominant responsible for the observed anomalies. Our study confirms that not all lensing anomalies are due to dark matter sub-halos and not accounting for the full complexity of the lenses may alter the results of statistical studies. The present study with a heterogeneous global-VLBI array can be considered a precursor of SKA-VLBI, which will give us access to a statistically significant strong lensing sample at sub-μJy sensitivity on milliarcsecond scales.

keywords:

Very Long Baseline Interferometry, gravitational lensing, cosmology, high redshift

In-person or online?:

unsure

Career level:

Student

Starbursts / Star-forming Galaxies / 91

A resolved and multiscale study of star-formation in local U/LIRGs

Author: Geferson Lucatelli[1]

Co-authors: Rob Beswick [2]; Javier Moldon [3]; MIGUEL ANGEL PEREZ TORRES [4]; Antxon Alberdi [5]

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[3] *IAA*

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[5] *IAA-CSIC*

As part of the e-MERLIN Legacy Project & Collaboration (LIRGI), this work has as objectives to stablish resolved calibrated star formation (SF) rates for local $(z < 0.1)$ Luminous and Ultra-Luminous Infrared Galaxies (U/LIRGs), and separating the emission related to active-galactic-nuclei (AGN). Detailed studies of local U/LIRGs play a fundamental role in the understanding of SF activity and how it is connected with AGN feedback and accretion mechanisms. This is essential for the inference of physical properties of distant U/LIRGs in later studies, where angular resolution is limited.

Our strategy is to use multiscale imaging and image processing techniques to decompose the radio emission into multi-components, at various spatial scales. We started by using *e*-MERLIN observations at 5 GHz and VLA observations at the same frequency, achieving angular resolutions from 0.05" to 0.3", respectively. With *e*-MERLIN, we resolve the nuclear regions at $\sim 20 - 50$ pc scales in order to probe compact radio components and disentangle it from the nuclear diffuse emission at scales $\sim 100 - 200$ pc. With VLA, we characterise the large scale diffuse emission (> 1 kpc), mostly associated with SF activity. To complement, we are now using multi-frequency observations (1.4

$\sim$ 33 GHz) to compute resolved spectral mapping to distinguish distinct mechanisms and calculate associated thermal fractions, thus achieving more accurate SFR estimates.

We introduce new techniques to take advantage of combined interferometric data, maximizing the science output from high-resolution images. We show how the entire process can be automated, thus appliable to larger datasets. We also present an automated and fast strategy for self-calibration of multi-frequency interferometric data, towards the reproducibility of science results.

Our first results demonstrated that the emission from SF processes (compact starburst, nuclear diffuse emission and large scale emission – i.e. multiscale SF emission) can be easily underestimated whilst AGN contribution overestimated. Thus, we present a multiscale SF tracer in order to quantify such differences and evaluate how SF is relevant to the radio emission.

keywords:

local galaxies; star-forming galaxies; ULIRGs; calibration; imaging; image fitting; image processing; automated techniques

In-person or online?:

in-person

Career level:

Student

Poster Sparklers / **104**

Abell 3667: understanding the nature of radio relics

Author: Alessandro Benati[1]

Co-author: Francesco de Gasperin [2]

[1] *INAF - IRA*

[2] *IRA INAF*

Galaxy clusters are the most massive virialized objects in the Universe, and they evolve through mergers of smaller substructures. Such cluster mergers are extremely energetic events, dissipating energy through shocks and turbulence in the intra-cluster medium (ICM). The most spectacular results of such merging activity can be observed in the radio band in the form of radio halos and radio relics. The latter are elongated and polarised sources found at the clusters outskirts, and their presence has been related to large cluster merger shocks induced in the ICM. The galaxy cluster Abel 3667 hosts a spectacular radio relic, unique for its brightness and size, and has been already observed in the L band (856–1711 MHz) using the MeerKAT telescope (de Gasperin et al. 2022). In this work, we present the MeerKAT's UHF band (544–1087 MHz) observation of such target, in order to combine the extracted information with the L-band one, allowing the derivation of resolved wide-band spectra and precise rotation measure measurements. As a consequence, we study the particle acceleration and fading processes locally, in isolated filaments, rather than analysing spectra integrated over larger regions, where this information is hidden. Furthermore, the 3D reconstruction of the filament geometry allows an extremely precise comparison with the predictions made by current cosmological and non-cosmological MHD simulations, where different models for particle acceleration can be explored. Moreover, the images of the shock front region at such low-frequency band enable a more robust Mach number estimation. Finally, the UHF-band view of this cluster allows for a spatially resolved study of the faint and extended radio halo formed as a consequence of a bullet-like merger.

keywords:

Galaxy clusters, radio relics

In-person or online?:

in-person

Career level:

Student

Galactic & AGN/ High-z / 48

Active galaxies in the LoTSS DR2 survey

Author: Martin Hardcastle[1]

[1] *University of Hertfordshire*

he second data release of the LOFAR Two-Metre Sky Survey (LoTSS) covers 27% of the northern sky, with a total area of ~ 5,700 deg^2. We have used a combination of automatic cross-matching, citizen science, and expert visual inspection to find optical identifications for around 3.5 million radio sources in the survey, generating by far the largest catalogue of identified radio sources ever and providing some important learning points for the SKA era. The unsurpassed statistics of the dataset allow us to pioneer new approaches to removing star formation contamination from AGN samples, generating of order 500,000 robustly selected AGN. These in turn allow new tests of radio AGN unified models, and greatly improved estimates of the importance of AGN feedback in the local universe. I'll discuss some preliminary results from these projects.

keywords:

cross-matching, AGN

In-person or online?:

in-person

Career level:

Mid-Senior

Clusters/LSS & AGN/High-z / 85

Ageing and rejuvenation: the tailed radio galaxies in Abell 2142

Author: Luca Bruno[1]

[1] *INAF-IRA, DIFA-UNIBO*

Radio galaxies moving through the intra-cluster medium with high velocities experience ram-pressure, which deflects their radio jets and re-shapes them into head-tail galaxies (HTs) typically spanning few hundreds of kpc. Electrons are initially ejected from the head (core), and then progressively age along the tail due to radiative losses. However, recent observations at low ($\sim$ 100 MHz) frequencies have unveiled HTs extending on megaparsec-scales and HTs exhibiting sudden flux density enhancements within the tail rather than the expected radial decrease. These observations challenge

standard ageing models and imply re-energising mechanisms occurring either in the ICM or within the tail itself. Therefore, HTs offer insights on the re-acceleration mechanisms and the interplay between thermal and non-thermal components in galaxy clusters, and the reservoir of seed (mildly relativistic) electrons in the ICM.

A2142 hosts two intriguing HTs, namely T1 and T2, currently under analysis with deep radio data in the range 50-2000 MHz. T1 is a giant HT extending for 700 kpc and showing localised re-energising features. T2 exhibits a peculiar morphology, with a choked tail culminating in a diffuse filamentary plume; preliminary results suggest that T2 is a dying HT. With our radio and auxiliary X-ray data, we test ageing models, discuss re-energising events, and investigate the role of dynamics and thermodynamics in shaping our targets. We finally speculate on the origin of electrons powering the emission of the 2 Mpc-scale radio halo in A2142.

keywords:

clusters, AGN

In-person or online?:

in-person

Career level:

ECR

Starbursts / Star-forming Galaxies / 58

Analyzing the Global Magnetic Field Configuration of Edge-On Galaxies with Radio Polarimetry Data

Authors: Michael Stein[1]; Ralf-Juergen Dettmar[2]; Björn Adebahr[3]

[1] *Ruhr University Bochum, Astronomical Institute*

[2] *Ruhr-University Bochum*

[3] *AIRUB*

In recent years, we learned that magnetic fields (B-fields) and cosmic rays (CRs) play a crucial role in shaping the evolution of galaxies and their halos, influencing processes from gas dynamics to accretion phenomena. A comprehensive exploration of these magnetic field effects is essential for advancing our understanding of the fundamental drivers behind galactic evolution. For this task, modern radio interferometers such as the Jansky Very Large Array (JVLA) or the Low Frequency Array (LOFAR) are essential as they allow us to trace CRs and B-fields through synchrotron emission in great detail.

When analyzing the magnetic field configuration of edge-on galaxies, many show distinctive "X-shaped"B-fields. Such a morphology already hints at the interesting interplay between thermal and non-thermal processes that govern the driving mechanisms of material from the galactic disk into the halo. To unravel the formation of this characteristic morphology, three dimensional analytical models are fitted to polarization-angle maps of multiple edge-on galaxies, utilizing data from the CHANG-ES Survey (Continuum Halos in Nearby Galaxies - an EVLA Survey). Additionally, a combination of JVLA and LOFAR data is employed to analyze cosmic ray transport within these galaxies, providing insights into the relative significance of CR-driven and thermal processes within the context of galactic winds.

Upcoming radio surveys, from the Square Kilometre Array (SKA) and its pathfinders, with high angular resolution and full polarization information, will significantly expand our sample, facilitating a detailed understanding of the magnetization process in galactic halos.

keywords:

galaxies, magnetism, polarization, cosmic rays

In-person or online?:

in-person

Career level:

Student

Surveys / **121**

Aper-V - The Apertif Circular Polarisation Survey

Author: Björn Adebahr[1]

[1] *AIRUB*

The circularly polarised radio sky is a big unknown in astronomy due to the scarcity of sources. It has been shown that objects such as pulsars, brown dwarfs, exoplanets, transient events and AGN can be circularly polarised. The fractions of circular polarisation for most of the detected sources reach some percent at most. Therefore, to examine the composition and characteristics of these sources untargeted large area widefield surveys performed with telescopes where the instrumental characteristics are well known are needed.

Recent analysis of survey data from the LOFAR and MWA telescopes covered 5634 deg^2 and 30900 deg^2 at 144 MHz and 200 MHz detecting 68 and 35 sources, respectively. Here we present the first results of an untargeted Stokes V survey at 1.4 GHz covering approximately 2000 deg^2 using the Apertif data. We will illustrate how to characterise the circular polarisation leakage behaviour of the Apertif phased array feeds and mitigate their influence for source identification. We will compare our results to the lower frequency surveys allowing us to investigate the spectral behaviour of the detected sources. In addition, the repeating observational setup of the Apertif surveys allows us to investigate a possible time evolution.

keywords:

survey overview, source finding, calibration, polarisation

In-person or online?:

in-person

Career level:

ECR

Techniques / **8**

Automated deep sub-arcsecond wide-field imaging of ELAIS-N1 with LOFAR

Author: Jurjen de Jong[None]

Recent work by Morabito et al. (2022) and Sweijen et al. (2022) introduced the first steps towards a wide-field imaging pipeline to reduce data from the Low Frequency Array (LOFAR) with all international stations included. Building upon their work, we have improved the pipeline for wide-field

imaging by investigating and testing additional pipeline steps to increase the image quality and automation of the pipeline with 32h of LOFAR data of the ELAIS-N1 deep field. This effort led to a wide-field image at a resolution of 0.3" and a sensitivity of 17 μJy/beam, marking the deepest wide-field image at this resolution and frequency. In addition, we also generated wide-field images at 0.6" and 1.2", enabling comparisons of source detections across resolution and sensitivity.

We would like to present this work, as it will bring us closer to the realization of a fully automated LOFAR VLBI pipeline and will allow for the development of surveys similar to the LOFAR Two-metre Sky Survey (LoTSS; Shimwell et al. 2017, 2019, 2022; Williams et al. 2019), improving the 'standard resolution' of LOFAR from 6" to 0.3". This is an important next step to reveal the science hidden among the 90% of radio sources that are currently unresolved in LoTSS.

keywords:

radio astronomy, wide-field imaging, VLBI, pipelines, automation, machine learning

In-person or online?:

in-person

Career level:

ECR

Clusters/LSS / 44

Bridging the gap: Mpc-scale diffuse radio emission between galaxy clusters

Author: Giada Pignataro[1]

[1] *Università di Bologna*

Evidence of radio synchrotron emission from bridges of low-density gas connecting pairs of galaxy clusters allows us to trace the filaments of the so-called cosmic web, along which the accretion of matter on galaxy clusters happens. The origin of the seed particles for the radio emission on Mpc-and over scales, is still not well understood. We aim to a more comprehensive understanding of the processes behind such emission, by working on promising pairs of galaxy clusters where their dynamical interaction is supported by the detection of a bridge of ionised plasma between them observed through the SZ effect. Abell 0399-Abell 0401 is a unique cluster pair found in an interacting state. Their connection along a filament is supported by SZ effect detected by the Planck satellite and the presence of a radio bridge has been already confirmed by LOFAR observations at 140 MHz. In this talk, I will present the the first the determination of a spectral index value for the bridge emission in A399-A401 using LOFAR HBA at 140MHz and LBA data at 60 MHz and the analysis on the spectrum between 60 and 400 MHz, with LOFAR and uGMRT observations. I will also present a preview of another candidate bridge in Corona Borealis. Looking ahead, the upcoming Square Kilometre Array (SKA) Observatory, with its unprecedented sensitivity and capability, promises to revolutionise our exploration of the universe. In particular with SKA-Low at very low frequencies we anticipate the ability to not only detect but also strengthen the models made now on radio bridges with unmatched precision.

keywords:

radio bridges, galaxy clusters, cosmic web, filaments, LOFAR

In-person or online?:

in-person

Career level:

Student

Clusters/LSS & AGN/High-z / 34

Connecting the fine structure of jets with the complex geometry of lobes in radio galaxies: a 144 MHz to 9 GHz, multi-scale radio journey in RBS 797

Author: Francesco Ubertosi[1]

[1] *University of Bologna*

A variety of radio sources have so far questioned the idea that AGN-driven jets are always stable, straight, linear outflows. A significant challenge in understanding how jets can change their orientation over time is related to the vast range of spatial scales involved, spanning from a few pc to tens of kpc. To illustrate the importance of high-resolution and sensitive observations for resolving these diverse scales, I will present our new investigation of the central radio galaxy in the RBS797 cluster. We conducted a comprehensive study of its multiple jet activities in different directions, employing multi-frequency (144 MHz - 9 GHz) and multi-scale (5 pc to 50 kpc) observations performed with JVLA, LOFAR (including international stations), e-Merlin, VLBA, and EVN. These deep and recent observations allowed us to spatially resolve the morphology, spectral features, and radiative age of the radio galaxy's components, namely its four perpendicular lobes, the precessing jets with multiple hotspots, and the heart of the radio core on pc scales. Our study underlines the critical need for high resolution observations that are also sensitive to large scale, diffuse radio emission (such as the LOFAR data with international stations, or the JVLA data), which will be provided by the SKA telescope. This is required to connect the fine structure of the jets in radio galaxies with the complex geometry of their large lobes.

keywords:

AGN, radio galaxies, sub-arcsecond resolution, multifrequency, multiscale analysis

In-person or online?:

in-person

Career level:

ECR

Clusters/LSS / 30

Constraining the origin of radio halos in galaxy clusters

Author: Thomas Pasini[1]

[1] *Hamburg University*

A number of galaxy clusters show extended, diffuse, synchrotron emission in their central region. These sources are called radio halos, and are produced by the (re-)acceleration of relativistic seed electrons that fill the magnetised plasma halo of galaxy clusters. However, the nature of the re-acceleration mechanism is unclear. The current leading scenario is based on second order Fermi mechanisms, which are poorly efficient and are predicted to generate a large population of radio halos with very steep spectra (⊠ < -1.5). In this talk, I will present an upcoming study where we provide strong evidence in favour of this scenario, using observations performed with LOFAR. By exploiting survey data from LoTSS and LoLSS of a sample of 11 radio halos, we prove for the first time that a large fraction (~65%) shows emission that fades quickly with increasing radio frequency,

implying an ultra-steep synchrotron spectrum. In addition, we find a trend between the cluster mass and the halo spectral index, with more massive clusters hosting flatter halos. The existence of a larger population of ultra-steep spectrum radio halos, with respect to flatter spectrum sources, further validates these models, which predict an increasing fraction of radio halos associated with less massive galaxy clusters. As a conclusion, I will also shortly present recent advances in our capabilities to calibrate LOFAR LBA-VLBI data.

keywords:

clusters, radio halos, particle re-acceleration, diffuse emission, calibration

In-person or online?:

in-person

Career level:

ECR

Surveys & Clusters/Lss / 61

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

Author: Gabriella Di Gennaro[1]

[1] *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.

keywords:

galaxy clusters; diffuse radio emission; BCG; uGMRT; MeerKAT

In-person or online?:

in-person

Career level:

Mid-Senior

Poster Sparklers / 64

DISENTANGLING STAR FORMATION AND AGN ACTIVITY IN THE GAMA (G23) REGION

Author: Harris Yao Fortune Marc[1]

[1] *University of Felix Houphouet Boigny*

We used a multiwavelength approach to study star-forming (SF) and active galactic nuclei (AGN)-dominated galaxies.
Unlike precedent works focused on individual wavelength regimes, we combined optical and infrared data, which we reprocessed using customized software in
order to enhance the data quality. This led to a better differentiation of the two main categories of galaxies that are indispensable to understanding galaxy
evolution (Yao et al. 2020). We incorporated early science continuum data from MeerKAT into our analysis (Yao et al. 2022).

Yao, H.~F.~M., Jarrett, T.~H., Cluver, M.~E., et al.\ 2020, \apj, 903, 91. doi:10.3847/1538-4357/abba1a

Yao, H.~F.~M., Cluver, M.~E., Jarrett, T.~H., et al.\ 2022, \apj, 939, 26. doi:10.3847/1538-4357/ac8790

keywords:

cross-matching, source finding, imaging, AGN, star-forming galaxies

In-person or online?:

in-person

Career level:

ECR

Galactic & AGN/ High-z / 124

Decoding DDRG growth and environment with the largest sample from LoTSS

Authors: Pratik Dabhade[1]; Kshitij Chavan[2]; Dhruba Jyoti Saikia[2]; Huub Rottgering[3]

[1] *Instituto de Astrofísica de Canarias (IAC, Spain)*

[2] *IUCAA*

[3] *Leiden Observatory*

Double-double radio galaxies (DDRGs) are key evidence of recurrent AGN activity, featuring two pairs of radio lobes, typically along a similar axis. These DDRGs, often displaying FR-II morphology, exhibit differences between their outer, diffuse lobes from earlier activity cycles and their more recent, hotspot-rich lobes. Variations in the restarting timescale or environmental inhomogeneities often result in offsets between these lobe pairs. DDRGs provide insights into the AGN duty cycle, with their morphology and radio spectra shedding light on episodic activity histories. They raise crucial questions about AGN triggering and fueling mechanisms, activity cycles, radio galaxy evolution, and AGN feedback processes. Understanding these aspects, particularly through studies of remnant and restarted galaxies like DDRGs, is vital. Here, low-frequency telescopes such as LOFAR play a key role, offering sensitivity to the diffuse and steep-spectrum plasma common in these sources.
As of 2016, only around 300 giant radio sources (size > 0.7 Mpc) were known, considered rare. Now, there are approximately 3300, with about 2500 identified via LoTSS. In contrast, DDRG numbers haven't significantly risen since 2017's count of 70, largely due to insufficient systematic searches in deep radio surveys.
To advance the above-mentioned studies, it's crucial to compile a large statistical sample of DDRGs and examine them alongside other radio galaxy phases, like remnants. DDRG identification relies primarily on radio morphology; while automating this process through machine learning is developing, it remains challenging. Therefore, manual visual inspection, despite being laborious, is currently

the most reliable method.
However, covering the vast 5700 sq deg of LoTSS DR2 sky manually is challenging. Notably, many known DDRGs are giants (>0.7 Mpc). To streamline our DDRG search, we utilized LoTSS DR2's list of nearly 2500 giant radio sources, identifying 84 new DDRGs exceeding 0.7 Mpc. Interestingly, a significant number of these DDRGs were not detected in high-frequency surveys like NVSS, underscoring their steep spectral characteristics and the critical role of LoTSS surveys. Interestingly, we also, found two radio sources with three episodes of jet activity (triple-double radio galaxy or TDRG), making it only the 4th and 5th such known so far. The unprecedented sensitivities achieved by the LoTSS survey at 150 MHz, unveiled many peculiar morphological traits associated with these sources, which we have attempted to characterise and explain. Hence, for the first time, we can characterise the low-frequency radio properties of a large sample of DDRGs.
Employing ancillary data from high-frequency radio surveys such as NVSS and APERTIF-WSRT, we estimated their integrated spectral indices in conjunction with LoTSS data. Furthermore, through higher resolution surveys like FIRST and VLASS, we determined the radio core properties and core dominance factors, crucial for investigating Doppler boosting and related asymmetries.
The high resolution and sensitivity of the LoTSS maps have been instrumental in estimating the arm-length and flux ratios of both inner and outer doubles. This analysis enables us to infer details about both the local and broader environments surrounding DDRGs by scrutinizing radio morphological asymmetries. Consequently, this serves as an effective probe for environmental conditions and their impact on source growth. Notably, in several instances, we observed a 'flipping of symmetry'—where the inner double is symmetric and the outer double asymmetric, or vice versa. This phenomenon offers unparalleled insights into the cocoons surrounding newer or inner doubles. Additionally, it allows us to comprehend how a restarted source propagates in such environments, its effects on the source itself, and subsequently on the duty cycle. Our systematic approach to this analysis, a first for such an extensive sample, proves to be exceptionally effective in advancing our understanding of DDRGs. We also uncovered numerous Gigahertz-Peaked Spectrum (GPS) candidates within our sample, along with several DDRGs being hosted by Brightest Cluster Galaxies (BCGs). Lastly, we correlated the radio morphological asymmetries with the optical morphology of the host galaxies to identify signs of mergers. In several cases, we observed a direct correlation, further enhancing our understanding of these phenomena. We aim to explain our methods and results via an oral contribution at the SPARCS meeting (2024).

keywords:

AGN, Restarted AGN, large sample study. environment

In-person or online?:

in-person

Career level:

ECR

Techniques / **77**

Deep Field Imaging of the GAMA9 and GAMA23 Regions

Author: Sean Paterson[1]

[1] *Curtin University*

Thousands of observations of the well-studied Galaxy and Mass Assembly (GAMA) fields, GAMA9 and GAMA23, have been conducted with the MWA (Murchinson Widefield Array) radio telescope for the MWA Interestingly Deep Astrophysical Survey (MIDAS) and the GAMA23 OverwheLming Deep (GOLD) survey. Here we present deep images of the GAMA9 and GAMA23 fields centered at a frequency of 215.68 MHz with a bandwidth of 30.72 MHz, produced from these observations obtaining an RMS below 1 mJy/beam. These deep field images will assist in determining source counts to produce low-frequency radio luminosity functions that can be used to analyse radio galaxy evolution.

In addition, we provide a detailed description of the automated Deep Imaging Pipeline (DIP) that enabled the creation of these images. DIP was adapted from the pipeline used in the GaLactic and Extragalactic All-sky MWA X (GLEAM-X) survey with improvements in the cleaning for deep imaging and automation to allow large batch processing with minimal user input.

keywords:

Deep Field GAMA9 GAMA23 GAMA MWA Survey Processing

In-person or online?:

online

Career level:

Student

Galactic / 114

Discovery of Bow-Shock Pulsar Wind Nebulae in the EMU Surveys

Authors: Sanja Lazarevic[1]; Miroslav Filipović[2]; Shi Dai[3]; Chandreyee Maitra[None]; Philip Edwards[4]; Adeel Ahmad[1]; Rami Alsaberi[5]

[1] *Western Sydney University*

[2] *western Sydney University*

[3] *CSIRO Astronomy and Space Science*

[4] *CSIRO Astronomy & Space Science*

[5] *Western Sydney university*

Pulsars and their Wind Nebulae exhibit intriguing features when moving at supersonic speeds through ambient medium, such as bow-shaped shocks and cometary tails. Studying the PWNe provides valuable insights into pulsars, radiative efficiency, properties of the surrounding medium, and the physics of the wind-medium interaction. Additionally, it contributes to our understanding of the distribution of the natal kick velocities that neutron stars acquire during supernova implosions.
The first report of this phenomenon dates back to 1987, and prior to the Chandra X-ray Observatory's launch in 1999, only a handful of PWNe had been identified. Chandra's enhanced capabilities have led to the identification of approximately 30 pulsars displaying signs of supersonic motion. However, recent advancements in radio-continuum surveys obtained with ASKAP and MeerKAT have transformed the rarity of these objects.
In this presentation, I will summarize the discovery and analysis of Potoroo, a remarkable bow-shock PWN with one of the longest radio tails, detected in the EMU pilot survey. The latter part of the talk will highlight the six best new examples of the class, showcasing a diverse range of morphologies. All discoveries have been made in the Galactic Plane fields of the EMU main survey, with promising prospects for more to come.

keywords:

pulsar wind nebulae, SNRs, galactic astronomy

In-person or online?:

online

Career level:

Student

Galactic & AGN/ High-z / 99

Discovery of a dominant new population of jet-mode AGN at high redshift

Author: Rohit Kondapally[None]

Active galactic nuclei (AGN) can have a significant effect on their host galaxies by regulating their growth or suppressing star formation (known as AGN feedback). Of particular importance for massive galaxies and clusters are jet-mode AGN which display powerful radio jets and keep galaxies 'red and dead'once quenched. However, until recently, the cosmic evolution of jet-mode AGN has remained largely unconstrained beyond z~1. The LOFAR telescope has been undertaking one of the deepest wide-field radio continuum surveys to date: this represents a novel sample to statistically study the evolution of AGN activity and feedback across cosmic time. Using this sample, I will present the first robust measurement of jet-mode AGN feedback out to z ~ 2.5. We discover a new dominant population of jet-mode AGN hosted by star-forming galaxies at high redshifts, that has not been previously observed. We find that the bulk of the AGN heating output is performed by this new population in the early Universe, highlighting their importance in early galaxy evolution. I will also present a detailed analysis of the host galaxy properties which finds evidence that this new class of AGN within star-forming galaxies is fuelled by a different mechanism compared to their quiescent counterparts. These results showcase the power of deep wide-area radio continuum surveys in characterising the nature of the faint AGN population across cosmic time.

keywords:

AGN; galaxy evolution

In-person or online?:

in-person

Career level:

ECR

Techniques / 108

Dynamic imaging with MeerKAT: is the time axis the final frontier?

Author: Oleg Smirnov[1]

[1] *Rhodes University & SKA SA*

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 uJy image rms in an 8s integration, which opens up studies of variability on much shorter timescales than was possible with previous 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 discuss these challenges, and present MeerKAT dynamic imaging of Jupiter's radiation belts, which have led to the serendipitous discovery of a pulsar/RRAT-class object. I will also present our plans for an imaging pipeline that will be capable of yielding light curves and dynamic spectra for thousands of field sources en masse, potentially turning any MeerKAT continuum survey into a "variability machine".

keywords:

imaging, calibration, transients, variables

In-person or online?:

in-person

Career level:

Mid-Senior

Techniques / **78**

EMU Pilot Survey - Redshifts Estimated using Machine Learning

Author: Kieran Luken[1]

[1] *Western Sydney University*

Measuring redshifts of radio sources is extremely important but extremely hard. I have been searching for the optimum machine learning algorithms to measure the redshifts of radio sources. One of the reasons that radio sources are visible at higher redshift is because of the active supermassive black hole at the centre of the galaxy. But this is also the reason a lot of traditional methods for estimating redshift fail. The emission from a black hole is difficult to separate from the emission from the stars forming inside the galaxy hosting that black hole, for example. My work compares simple, traditional machine learning algorithms like the k-Nearest Neighbours (kNN) and Random Forest algorithms, with much more complex algorithms based around Neural Networks and Gaussian Processes. We find that as long as the available model parameters are optimised, the simple kNN algorithm performs best for our use case, although it does have its limitations. Using this technique, I have estimated the redshift of 100,000 radio sources in the Evolutionary Map of the Universe Pilot Survey, many of which have never been seen before at radio wavelengths.

keywords:

machine learning, redshift

In-person or online?:

unsure

Career level:

Student

Surveys / **54**

Early science with GLEAM-X and what's next?

Author: Kathryn Ross[1]

[1] *ICRAR - Curtin*

The GaLactic and Extragalactic All-sky MWA eXtended (GLEAM-X) survey boasts twice the resolution, and up to an order of magnitude higher sensitivity to its predecessor the GLEAM survey. In 2020, observations for GLEAM-X were completed and the first data release covering 2,000 square

degrees down to an RMS noise level of <1.5 mJy/beam was recently released. The second data release, covering an RA range from ~20h to 6h and Dec<+30, has an improved RMS noise level of <1mJy/beam, and ~650,000 sources with spectral fitting. In this talk, we will showcase early science results from the second data release including spectral variability of peaked spectrum sources, cosmology, and tomography of ionospheric disturbances.

keywords:

surveys overview, survey science, AGN, imaging, variability

In-person or online?:

unsure

Career level:

ECR

Poster Sparklers / **128**

En route to the SKA era: MeerKAT's sharp new view on galaxy clusters

Author: Konstantinos Kolokythas[1]

Co-authors: Tiziana Venturi Venturi [2]; Kenda Knowles [3]

[1] *Rhodes University*

[2] *INAF, Istituto di Radioastronomia*

[3] *Rhodes University / South African Radio Astronomy Observatory*

Radio observations of galaxy clusters are powerful tools for detecting diffuse cluster-scale synchrotron emission, which carries information about the cluster formation history. Observations using Square Kilometre Array (SKA) precursor and pathfinder instruments are nowadays opening up a new window on diffuse cluster radio sources and challenge our simple classification scheme (radio halos, mini-halos, and radio relics), making clear the need for an update of our current knowledge. Towards this direction, the unique combination of the MeerKAT radio telescope's unprecedented high sensitivity to low surface brightness emission, dense uv-coverage, and high resolution is key to the re-discovery of galaxy clusters and in-depth comprehension of the diffuse structures formation mechanism. In this talk, I will summarize the results from MeerKAT's Galaxy Cluster Legacy Survey (MGCLS) diffuse radio emission catalogue, a program of long-track observations of 115 galaxy clusters at 1.28 GHz spread out over the Southern sky focusing on the statistics and properties of the various diffuse radio emission structures detected in MGCLS galaxy clusters. New results on individual systems will also be highlighted to reveal both the much-improved radio images compared to previous radio observations and the discoveries that open up new areas of investigation in cluster formation and evolution that set the path to the SKA era.

keywords:

galaxy clusters, diffuse radio emission, survey overview

In-person or online?:

in-person

Career level:

Mid-Senior

VLBI & Cosmology / 25

Enhanced Imaging With e-MERLIN

Author: Tom Muxlow[1]

[1] *Jodrell Bank Centre for Astrophysics*

This presentation seeks to illustrate recent (and ongoing) e-MERLIN enhancements in imaging capabilities which are starting to be delivered from a combination of continued software developments and a funded programme of digital upgrades to the existing e-MERLIN hardware.

These enhancements are being rolled out and the presentation will illustrate how e-MERGE L-Band data taken between 2014 and 2016 will finally be fully imaged across the full field of view of the 25m diameter antennas including the 32m Cambridge dish together with the 76m diameter Lovell telescope by the incorporation of detailed beam models. With the addition of uv-averaging to the imaging step, all the many TB of (substantially interference-free) historical data can then be incorporated into a single sub-μJy sensitivity image.

The last few e-MERGE C-Band datasets are finally being observed –again with the full range of e-MERLIN antenna sizes and with dual C-Band frequencies centred at 4.75GHz and 6.25GHz (for enhanced uv-coverage) over a 7-point mosaic covering the central 10 arcminute diameter of the L-Band field. Again, imaging developments utilised in the L-Band imaging will be extended to the more complex C-Band imaging.

Enhanced e-MERLIN + Western EVN imaging of M82 SNR will be shown to illustrate enhanced resolution imaging intermediate between e-MERLIN and full EVN resolution, matched to the study of recent (less than a few hundred years old) supernova remnants in the nuclear region of M82 which are very heavily resolved at full EVN resolution. The digital upgrade will ultimately allow increased bandwidth of e-MERLIN observations with the EVN which will improve the sensitivity of the combination imaging.

The digital upgrade will ultimately allow the existing (and aging) WIDAR correlator to be replaced by a software correlator which can be scaled for increased observing bandwidths in the future.

keywords:

Imaging, galaxies

In-person or online?:

in-person

Career level:

Mid-Senior

VLBI & Cosmology / 88

Gravitational lensing with SKA-VLBI precursors: testing the ΛCDM model at milliarcsecond scales

Author: Cristiana Spingola[1]

[1] *INAF - Institute for Radioastronomy*

Current cosmological controversies are coming down to the precision level of observations. Future wide-field surveys with the next generation of telescopes will open the so-called “era of precision

cosmology", but that era has already started at the radio wavelengths with Very Long Baseline Interferometry (VLBI). The powerful combination of strong gravitational lensing and VLBI observations eases the study of the sub-galactic scales at cosmological distances, directly testing the basic assumptions of our current cosmological framework.
In this talk, I will show our recent results on the constraints on the nature of dark matter from the analysis of giant gravitational arcs observed with global-VLBI. These results are as stringent as those derived from the Lyman-α forest observations of cosmic structure and from the number statistics of the observed satellites of our Galaxy. Our work demonstrates the power of this method and anticipates what SKA-VLBI will be able to reveal.
Nevertheless, there are currently only a handful of extended radio-loud arcs known. I will discuss the on-going efforts and future prospects for searching for lenses in wide-field radio surveys. The SKA1-MID surveys are expected to reveal ~10^5 strong lenses, but only with the VLBI capability it will be possible to follow-up the most promising objects at an unprecedented sensitivity and milliarcsecond angular resolution. With the (very) long baselines, SKA-VLBI will unveil also the faintest gravitational arcs, providing the statistical significant sample needed to finally determine the mass of the dark matter particle.

keywords:

VLBI; cosmology; radio-continuum; gravitational lensing; AGN; source finding

In-person or online?:

in-person

Career level:

ECR

Surveys / **2**

LOFAR LEGACY 60 MHZ SURVEY OF THE 3CRR CATALOGUE

Author: Jort Boxelaar[1]

Co-author: Francesco de Gasperin [2]

[1] *IRA - INAF*

[2] *IRA INAF*

The Low Frequency Array (LOFAR) is currently the only instrument capable of deep, high-resolution imaging at frequencies below 100 MHz. Sources selected from the 3C catalogue are some of the best studied powerful radio galaxies, with the largest number of available sensitive and high (kpc-scale) resolution images at GHz frequencies, (still) driving our current understanding of their dynamics and energetics. However, a lack of instruments with sufficiently long baselines (combined with short baselines) at frequencies below 1 GHz, or a lack of robust calibration strategies, has prohibited any highly-resolved radio galaxy studies in the MHz regime. Observing at these low frequencies using the Low Band Antenna (LBA) system has proven challenging. However, over the past few years, our team has developed tools and strategies to solve both instrumental and ionospheric systematic errors, producing thermal noise limited images. With this work we calibrate and image the observations of the entire 3C(RR) catalogue. The final goal is to obtain a flux-limited legacy catalogue of radio images with the following unique combination of characteristics: (I) an observing frequency of 60 MHz, (II) a high resolution (< 10″), and (III) good sensitivity to large scale emission.

keywords:

imaging, calibration, survey overview, clusters, AGN

In-person or online?:

in-person

Career level:

Student

VLBI / **63**

LoTSS-HR: The high-resolution post-processing of the LOFAR Two-Metre Sky Survey

Author: Roland Timmerman[1]

Co-authors: Leah Morabito [2]; Neal Jackson [3]; Martin Hardcastle [4]; James Petley [1]; Timothy Shimwell [5]

[1] *Durham University*

[2] *Durham*

[3] *University of Manchester*

[4] *University of Hertfordshire*

[5] *Leiden University*

The LOw Frequency ARray (LOFAR) is one of the world's leading observatories at low radio frequencies. With its pan-European baselines reaching up to 2000 km in length, it is capable of achieving sub-arcsecond angular resolution at frequencies below 200 MHz. However, the use of its international baselines has been hindered for most of the current lifetime of the observatory, due to technical and logistical challenges: its phased-array design, the ionosphere, lack of known suitable calibrator sources, and lacking software tools. For this reason, many projects, including the LOFAR Two-Metre Sky Survey (LoTSS), have relied only on the Dutch part of the array, using baselines up to 120 km. Thanks to the Long Baseline Working Group, a strategy has been developed to enable the calibration of the international stations. This has unlocked the highest resolutions (~0.3 arcseconds) attainable with LOFAR, enabling a large variety of research for the first time. Equipped with the newly developed LOFAR-VLBI pipeline, we have started working on post-processing all previous LoTSS observations to provide high-resolution (0.3") and intermediate-resolution (1.2") images of all bright sources covered by these LoTSS observations to the public. In this talk, I will give an overview of the LoTSS-HR project, including the details of the calibration strategy, the current status of the project and the future outlook.

keywords:

survey overview, imaging, calibration, VLBI

In-person or online?:

in-person

Career level:

ECR

Techniques / **46**

Low frequency transient searches –a LOFAR perspective

Author: Iris de Ruiter[1]

[1] *Anton Pannekoek Institute/University of Amsterdam*

In this talk, I will discuss our efforts to explore the dynamic radio sky with LOFAR, the Low Frequency Array. Using automated transient pipelines, we have performed blind transient searches on various fields. I will specifically focus on the searches for transient sources on timescales of seconds to hours. In this regime, the main challenge is to image the data, and I will discuss various techniques we have developed to speed up the imaging step in the context of transient searches. Additionally, I will describe some of the efficient filtering techniques that we have developed. Despite these efforts, only 2% of the LOFAR data has thus far been processed on these second to minute timescales. However, in this small dataset, we have discovered an interesting transient source, which shows a few minute duration flares throughout five 8 hour observations. I will give an update on the most recent follow-up observations of this transient source. The discovery of this source in a small data set shows the incredible potential of exploring the low frequency radio sky on a second to minute cadence. Finally, with LOFAR2.0 we plan to run a fully automated version of the transient pipeline on all LOFAR interferometric observations, which I will detail in short in this talk.

keywords:

imaging, transients

In-person or online?:

online

Career level:

Student

Clusters/LSS & AGN/High-z / 87

MALS Data Release I: Probing Evolution of Cold gas in AGNs

Authors: Partha Pratim Deka[1]; Neeraj Gupta[1]; MALS Collaboration[None]

[1] *IUCAA*

The MeerKAT Absorption Line Survey (MALS) has observed 391 telescope pointings at L-band (900-1670 MHz) at declination<20 deg. In this talk, I'll present the radio continuum images and a catalog of 495,325 (240,321) radio-sources detected at SNR> 5 over an area of 2289 deg^2 (1132 deg^2) at 1006 MHz (1381 MHz). With excellent continuum (20 microJy/beam) and spectral sensitivity (0.5 mJy/beam per 6 km/s channel), this catalog will form the base catalog for future HI 21-cm and OH 18-cm absorption line search, addressing main theme of MALS : evolution of cold gas in galaxies upto z~2. Through comparisons with NVSS and FIRST at 1.4 GHz, we established the catalog's accuracy in the flux density scale and astrometry to be better than 6% and 0.8", respectively. We estimated spectral indices of a subset of 125,621 sources, confirmed the flattening of spectral indices with decreasing flux density and identified 140 ultra steep-spectrum (alpha<-1.3) sources as prospective high-z radio galaxies. From the catalog, we have also identified 1308 variable and 122 transient radio-sources composed primarily of AGNs that demonstrate long-term (26 years) variability in their observed flux densities. The MALS catalogs and images are publicly available at https://mals.iucaa.in. The talk will also cover the detection of HI 21-cm absorption associated with a quasar at z=1.353. By analyzing this source with literature samples of quasars and radio-galaxies with HI absorption, we conducted a joint radio and optical analysis to constrain the location and properties of cold gas in quasars versus galaxies.

keywords:

Radio surveys, Catalogs, source finding, imaging, Cold gas in AGNs

In-person or online?:

in-person

Career level:

Student

VLBI & Cosmology / 90

Measuring the cosmic radio dipole with MeerKAT

Author: Jonah Wagenveld[1]

[1] *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.

keywords:

Cosmology, continuum, surveys

In-person or online?:

unsure

Career level:

Student

Poster Sparklers / 65

MeerKAT Observations of the Abell 141 Galaxy Cluster

Author: Savannah Stanbury[1]

Co-authors: Oleg Smirnov [2]; Gianni Bernardi [3]

[1] *Rhodes University*

[2] *Rhodes University & SKA SA*

[3] *SKA SA & Rhodes University*

Galaxy clusters are one of the largest, gravitationally bound structures in the universe, hosting a hot, tenuous gas that permeates their volume, known as the intracluster medium. A fraction of the intracluster medium is composed of relativistic electrons that, when accelerated in magnetic fields, radiate synchrotron emission. Synchrotron emission occurs on scales ranging between individual galaxies to ∼Mpc scales and beyond, with two examples of radio emission observed on Mpc scales, “bridging” between cluster pairs. A possible third system to host radio emission on such large scales

is the Abell 141 (hereafter, A141) cluster, a system composed of two subclusters, where X-ray emission has been seen in the connecting region. Radio observations at 150 MHz and 943 MHz detected diffuse emission from the two systems, although the limited angular resolution prevented a detailed picture of the system.

In this thesis, we present observations at 1.28 GHz of the A 141 system, taken with the MeerKAT telescope, with the aim to further characterize its diffuse radio emission. We obtain an image with a $5.1'' \times 4.4''$ angular resolution with an RMS noise of 9 μJy~beam^{-1} that we use to identify and subtract compact sources. Subsequently, we generate a
$19'' \times 17''$ angular resolution with an RMS noise of 8.8 μJy~beam^{-1} where we detect diffuse radio emission extending over 0.9~Mpc. We find its integrated flux density to be 10.8 ± 0.3~mJy.

The radio surface brightness peaks at the location of the Northern subcluster, although, it is offset by a few arcmin with respect to the peak of the X-ray emission. The radio morphology extends over both subclusters, and, thanks to the angular resolution of our observations, we can clearly see radio emission in the region between the two subclusters, though it does not closely follow the X-ray morphology.

In this respect, A141 remains a somewhat unique system. We find tentative evidence for "bridge"-like radio emission at GHz frequency, which closely matches the morphology of the X-ray/thermal emission. Notably, previous "bridges" were detected at low frequency only (< 200~MHz). We confirmed the spectral index of the integrated radio emission to be -1.06 ± 0.09, which would somewhat disfavour a scenario where particles are accelerated by turbulence in the early merger state. This scenario is, conversely, the preferred explanation for the bridges detected at low frequencies. Further observations at lower frequencies may be able to shed light on the nature of this system.

keywords:

galaxy clusters, calibration, imaging, galaxy merger, intra cluster medium, radio continuum

In-person or online?:

in-person

Career level:

Student

Starbursts / Star-forming Galaxies / 92

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

Author: Malebo Moloko[1]

[1] *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 (Lir>1011 L⊙) 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 σ ≈ 20 μJy/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.

keywords:

local galaxies, star-forming galaxies, AGN

In-person or online?:

in-person

Career level:

Student

Galactic & AGN/ High-z / 134

Multi-Frequency Analysis of Megaparsec-scale DDRGs: Spectral Ageing and Duty Cycle Dynamics of Inner and Outer Lobes

Authors: Mousumi Mahato[1]; Pratik Dabhade[2]; Dhruba Saikia[3]

[1] *University of Tartu*

[2] *Instituto de Astrofísica de Canarias (IAC, Spain)*

[3] *Inter-University Centre for Astronomy and Astrophysics*

One of the most outstanding issues regarding active galactic nuclei (AGN) is the recurrent activity in AGN. Notable evidence of intermittent nuclear activity in AGN is found in the form of double-double radio galaxies (DDRGs), characterised by the presence of two pairs of radio lobes, typically aligned along the same jet axis, indicating two distinct cycles of activity. Investigating the properties of DDRGs is of utmost importance to refine our understanding of the duty cycle of AGN activity and feedback processes in AGN. This study allows the reconstruction of episodic activity history through the analysis of radio spectra and the information of source morphology. The study of megaparsec-scale DDRGs (size > 0.7 Mpc) holds particular significance as their vast dimensions aid a clearer distinction between two episodes of activity, unlike smaller DDRGs (~300 kpc). This larger volume coverage and reduced likelihood of emission overlap from different epochs make them relatively easier to analyse.

In our ongoing research, we have selected a sample of 14 megaparsec-scale (or giant) DDRGs from the LOFAR Two-metre Sky Survey (LoTSS) sample (Dabhade et al. 2020a). These DDRGs, with their high-quality LOFAR 144 MHz maps, form the cornerstone of our investigation. Crucially, low-frequency observations are key in accurately determining injection indices. Our objectives include determining the injection spectral indices of the newer and older activity represented by inner and outer doubles and scrutinising potential differences. We aim to estimate their spectral ages and constrain the duty cycle of AGN activity. In addition, our study focuses on examining the propagation of jets within the cocoon formed during the initial cycle, along with exploring the physical conditions and re-acceleration processes within the lobes. To achieve this, we have harnessed a wealth of multifrequency data, systematically acquired through our dedicated uGMRT band 4 (550-900 MHz) and JVLA S (2-4 GHz), C (4-8 GHz), and X (8-12 GHz) band observations. The strategic use of JVLA arrays across all frequencies has been pivotal, enabling us to obtain high-resolution arcsecond maps. These detailed maps are essential for our comprehensive analysis, allowing us to scrutinise the overall spectral characteristics, precisely identifying spectral breaks and accurately estimate spectral indices, injection indices for two cycles of activity, spectral ages and magnetic fields

of various components. They also facilitate the study of variations in these properties across different parts of the sources, such as lobes and plumes. Therefore, the combination of uGMRT and JVLA data, alongside the pre-existing LOFAR dataset, provides us with expansive frequency coverage from 144 MHz to 12 GHz, integral to our multifaceted study. We can also possibly examine and model particle re-acceleration if present in the lobes. This study stands out as the pioneering exploration into the mapping and analysis of giant DDRGs across such a wide range of frequencies. Previous studies on spectral ageing in DDRGs were conducted, but they were limited to a handful of sources and lacked the extensive frequency coverage that our sample study offers.. Through our observations from the C & D arrays of JVLA, we have successfully captured most of the diffuse emissions associated with the DDRGs.

In the presentation at SPARCS meeting (2024), we will highlight a segment of our work specifically featuring a subset of 10 sources from our sample. Our focus will be on unveiling findings derived from our recent observations conducted with uGMRT and JVLA, placing particular emphasis on the spectral ages of both inner and outer components of giant DDRGs. Additionally, we will present the outcomes of modelling our source evolution, employing the JP and KP models facilitated by Broadband Radio Astronomy Tools (BRATS). We will also present our examination of asymmetries in the inner and outer doubles. Additionally, our findings delve into understanding the effects of the surrounding environment on these asymmetries and their potential connections to spectral age variations.

In the future, our aim is to conduct a comparative study involving small sized DDRGs. The primary objective is to discern potential differences in the duty cycle of AGN activity and particle acceleration mechanisms. This investigation aims to shed light on the factors that contribute to the growth of DDRGs, allowing them to manifest as giants.

keywords:

AGN, restarted AGN, multifrequency observation

In-person or online?:

in-person

Career level:

Student

Galactic & AGN/ High-z / 32

New radio continuum surveys and the life-cycle of radio AGN

Author: Raffaella Morganti[1]

[1] *ASTRON/Kapteyn Institute Groningen (NL)*

New radio continuum surveys - and in particular those at low frequencies - have given the opportunity to expand the selection and characterisation of remnant and restarted radio AGN. This is crucial in order to learn more about the life-cycle of these objects and relate it to AGN feedback.
I will present the latest results that we have obtained making use of images from LOFAR 150 MHz, which we have also combined, when possible, with Apertif 1.4 GHz images to derive resolved spectral index images.
With our pilot project focused on the Lockman Hole region, we have derived the fraction of remnant and restarted radio sources and compared with the prediction of models of radio source evolution.
The study the central regions of some of the candidate radio sources has been also followed up with images obtained with the LOFAR International Baselines (0.3 arcsec resolution).
Using what we have learned from all this, we are now expanding the search of remnant and restarted radio sources to larger areas (like the HETDEX region) to improve the statistics of these rare objects and the study of their properties. I will report on the results so far.

keywords:

AGN, morphology, spectral index

In-person or online?:

unsure

Career level:

Mid-Senior

Techniques / **17**

Numerical simulations keeping up with the complexity of radio discoveries

Author: Franco Vazza[1]

[1] *Università di Bologna*

In the latest few years, a series of exciting discoveries by SKA's precursors and pathfinders have made the life of theorists harder, by showing that a plethora of new complex information must be accounted for in order to explain observations: the topology of magnetic fields, the actual details of their origin, the complex life cycle of radio galaxies within their halos, the time dependent evolution of relativistic particles across many different cycles of re-acceleration events.
In this contribution, I will show how numerical simulations are trying to keep up with this complexity, by designing new methods and resorting to large High Performance Computing facilities, in order to couple cosmological evolution with the new necessary ingredients (e.g. seeding from radio galaxies, ubiquitous Fermi acceleration processes, role of different magnetic field seeding processes) and with the new tough requirements on volume coverage and on the spatial and spectral resolution posed by future SKA surveys.

keywords:

cosmological simulations, radio emission, polarisation, radio galaxies

In-person or online?:

in-person

Career level:

Mid-Senior

Starbursts / Star-forming Galaxies / **41**

Odd Radio Circles Four Years On

Authors: Ray Norris[1]; Baerbel Koribalski[2]; Peter Macgregor[3]

[1] *CSIRO*

[2] *CSIRO Astronomy and Space Science*

[3] *Western Sydney University*

It is now four years since we discovered ORCs - faint radio circles about a million light years diameter surrounding galaxies at a redshift of around 0.5. We now know they come in at least 2 varieties (single and double), and that there are many "ORC-lookalikes" which resemble ORCs but don't have the characteristic edge-brightened ring of ORC1, which remains the archetypal ORC. We now know that they are even rarer than we first thought, and we were very lucky to have found one in the EMU pilot survey. We know that the higher sensitivity of Meerkat doesn't find a new population of fainter ORCs, and we have recent spectroscopy of a host that shows a smoking gun from the outburst that caused the ORC. And yet we don't seem much closer to understanding the mechanism that generated them. Here we will present new unpublished data, review the progress that has been made, and compare the competing models of mechanism that might have generated them.

keywords:

ORC AGN

In-person or online?:

online

Career level:

Mid-Senior

Techniques / **136**

On-The-Fly interferometric imaging using MeerKLASS survey

Authors: K. Rozgonyi[None]; M. G. Santos[None]; O. M. Smirnov[None]; J. J. Mohr[None]; K. J. B. Grainge[None]; D. H. Lang[None]; S Chatterjee[1]

[1] *PDF, University of the Western Cape*

MeerKLASS, the MeerKAT Large Area Synoptic Survey, aims to survey large areas of the sky with MeerKAT in order to probe cosmology using the single-dish HI intensity mapping technique while producing continuum images with the interferometer. The target is to cover 10,000 square deg on the UHF band with 25 uJy rms and 13"resolution (a new survey in the L-band with the MeerKAT extension aiming at 5,000 square deg, 9 uJy rms and 5"resolution has also been proposed). The single-dish survey requires a fast scanning mode at constant elevation in order to deal with systematics. This requires the use of the "On-The-Fly"(OTF) interferometric imaging technique to enable commensal observing for intensity mapping and interferometric imaging. OTF has been used previously by the VLA since it enables fast survey speeds while removing the settle-and-slew overhead from traditional step and stare observations. In this work, we demonstrate that science-quality OTF interferometric continuum imaging with fast scanning speeds is possible with MeerKAT, using available MeerKLASS data. However, OTF imaging comes with its own set of challenges, such as flux errors due to phase smearing or flux biases due to the motion of the pointing centre on the sky during the correlator integration time. We develop a framework to transform MeerKLASS scan observations into OTF-format measurement sets and mitigate these issues. We use these measurement sets to produce OTF interferometric imaging snapshots and employ two different techniques to add multiple OTF snapshots. Till now we have processed ~2700 of such OTF snapshots in the L-band, which covers about 300 square degrees in the Southern sky. With this fractional processed observation we have achieved an image sensitivity of ~140 uJy and we aim to reach about 30 uJy with the existing observations. In the future, with many fold data acquisition by the MeerKLASS survey, we expect to embark on the search for slow transient and deep imaging.

keywords:

survey overview, imaging, calibration, cosmology

In-person or online?:

in-person

Career level:

ECR

VLBI / **69**

Opening up the radio sky with VLBI

Author: Jack Radcliffe[1]

[1] *University of Pretoria / University of Manchester*

In the past few decades, radio surveys have provided us with unique insights into many areas of astrophysics such as star formation, supernovae, active galactic nuclei, pulsars, cosmology and much more. A key aspect of these surveys is the technique of Very Long Baseline Interferometry (VLBI) which can provide some of the highest resolutions possible in astronomy. This method has been crucial in understanding the inner workings of galaxies such as AGN-star-formation feedback, dark-matter substructures in gravitational lenses, and providing the first two direct images of a black hole shadow. VLBI has been typically limited where the largest surveys require many years of observations to build up an extensive sample. However, computational improvements have enabled us to map multiple sources within a single VLBI survey and push into the lower frequency regime through the International LOFAR telescope. In this talk, I will talk about the scientific and technical discoveries arising from such surveys and focus on the bright future of VLBI surveys. This includes the transition from the current modus operandi of a small number of surveys of a few 'famous' deep fields to a ubiquitous VLBI survey instrument. I will conclude the talk by talking about the upcoming developments in VLBI, such as the incorporation of SKA and MeerKAT, ultra-wideband receivers, and GPU-accelerated correlation and calibration.

keywords:

surveys, future instruments, AGN

In-person or online?:

online

Career level:

ECR

Surveys / **50**

POlarization Sky Survey of the Universe's Magnetism

Author: Cameron Van Eck[1]

[1] *Australian National University*

The POlarization Sky Survey of the Universe's Magnetism (POSSUM) is ASKAP's large continuum polarization survey, mapping the diffuse polarization of the southern sky in amazing detail and cataloging polarized radio sources and their Faraday rotation. We expect to achieve a 1.5 order of magnitude leap in the sky density of polarized sources compared to currently available data, and a similar improvement in the typical measurement uncertainty.
Since the last SPARCS meeting, POSSUM has reached two exciting milestones: survey observations have begun and the survey pipelines are processing data. I will present the design and status of POSSUM, show off a few early results, and highlight some novel things we're trying to advance

survey science. Time permitting, I'll also talk about the data pipeline design, the lessons learned building it, and the implications for SKA-era surveys.

keywords:

survey overview, polarization, ASKAP, pipelines

In-person or online?:

in-person

Career level:

ECR

Galactic & AGN/ High-z / 89

Peering into the unknown with COSMOS LOFAR and JWST observations

Author: Eleni Vardoulaki[1]

[1] *Thüringer Landessternwarte Tautenburg*

In the era of state-of-the-art radio observations, paving the way to the SKA, the necessity of multi-wavelength and multi-frequency observations has been established as the only approach to understanding the radio source populations. This is demonstrated in all its glory via the panchromatic dataset of the COSMOS field, with the latest additions of the LOFAR and JWST datasets. Approaches as such enable us to image in high resolution and sensitivity the active galactic nuclei (AGN) radio population and extract information about the radio properties and their interaction with the environment. I will discuss the latest LOFAR DDT 48h observations of the COSMOS field at 144 MHz at 6" and 1"and how, in combination to multi-frequency (from 144MHz to 3 GHz) and multi-wavelength (X-ray to radio) data from the panchromatic dataset of COSMOS, they help us understand the nature of the radio source populations and their interrelation to their hosts and large-scale environment (e.g. galaxy groups, density fields, and cosmic web). I will lastly present our efforts to study the physical properties and hosts of radio AGN using LOFAR and JWST sub-arcsec observations.

keywords:

AGN, galaxies, environment, galaxy groups, multi-wavelength, multi-frequency

In-person or online?:

online

Career level:

Mid-Senior

Clusters/LSS & AGN/High-z / 74

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

Author: Marisa Brienza[1]

[1] *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. Direct observations of this phenomenon have always been challenging but, thanks to the SKA precursors/pathfinders, in recent years, we are taking major steps forward.
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 shows, for the first time, that even after hundreds of Myr the AGN jet-inflated bubbles can still be not thoroughly mixed with the intragroup medium. Instead, they can be shredded into intricate filamentary structures, whose physics is still puzzling. Here, I present a broad-band resolved spectro-polarimetric analysis of this system, performed using data from our multi-frequency campaign spanning from 53 to 1500 MHz using LOFAR, uGMRT, MeerKAT, and VLA telescopes. Through the use of techniques such as spectral index maps, color-color plots, shift-plots and polarisation analysis, we obtain unique insights into the physics of the system including the 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 and anticipates the new opportunities offered by the SKA observatory.

keywords:

AGN jets, feedback, non-thermal plasma, filaments, duty cycle

In-person or online?:

in-person

Career level:

Mid-Senior

Poster Sparklers / 111

Primordial Magnetic Fields as seen by the Rotation Measure analysis in the rarified cosmic regions

Author: Salome Mtchedlidze[1]

[1] *University of Bologna, Ilia State University*

Radio-frequency surveys from the Square Kilometer Array (SKA) pathfinders and precursors (along with the future SKA surveys) shape (will be shaping) our views on the unresolved questions of Astrophysics and Cosmology. Some examples of such questions include how and when the Universe was magnetised and what was the role of magnetic fields in forming the large-scale structure. The radio emission, observed on galaxy and galaxy cluster scales, and possibly detectable far beyond these scales with future surveys, trace the large-scale magnetisation of the Universe. In my work, we strive to understand what is the origin of these large-scale magnetic fields (LSMFs) and whether the seed fields coming from the early Universe, i.e., primordial magnetic fields (PMFs), are viable candidates for explaining the observed properties of LSMFs. In my talk, I will discuss the results from our magnetohydrodynamic (MHD), cosmological simulations aiming to produce the mock Rotation Measure (RM) data. We construct the deep light cones by stacking the simulated boxes until redshift 2 focusing on the RM in the rarified regions of the cosmic web (i.e., the residual RM, RRM). We study different PMF models having different coherence scales to understand how the observational RRM evolution translates into constraints on the PMF strengths. In the second part of the talk, I will also present our ongoing work on simulating the realistic radio galaxies. For the first time, we are simulating magnetised jets in cosmological simulations with a realistic magnetic field structure ejected from the active galactic nuclei.

keywords:

Rotation Measure, large-scale magnetic fields, primordial magnetic fields, cosmological simulations

In-person or online?:

in-person

Career level:

ECR

Poster Sparklers / **83**

Probing Early Universe using the uGMRT, and SKA

Authors: Abhirup Datta[1]; Rashmi Sagar[2]; Anshuman Tripathi[3]; SAMIT PAL[4]

[1] *Department of Astronomy, Astrophysics and Space Engineering, Indian Institute of Technology-Indore,*

[2] *IIT Indore*

[3] *Student*

[4] *IIT INDORE*

The detection of the redshifted 21-cm signal of neutral hydrogen is a promising probe to study physical processes in the early universe, from the Cosmic Dawn (CD) to the Epoch of Reionization (EoR). This quest has been extremely hard at low radio frequencies due to severely bright foregrounds, ionospheric corruption, radio frequency interference (RFI), and instrumental systematics.
Here, we will present some recent uGMRT observations of the ELAIS-N1 field within the band-2 (120–250 MHz). This corresponds to the redshift range of 4.7–10.8. A significant feat is achieved with substantial 32-hour observations and an operational bandwidth of approximately 100 MHz. The resultant image reached an RMS noise level of 236 Jy/beam, the deepest image so far in this band of uGMRT. We will present glimpses of the data analysis and the final constraints obtained on the cosmic HI signal from the Cosmic Dawn and EoR. We have developed an end-to-end pipeline to study how systematics affects the extraction of the redshifted HI 21cm signal from future SKA-1 Low observations. In order to probe the Dark Ages, we rely on observations made from space in the absence of Earth's ionosphere and free from the RFI. One such location is the far side of the moon. Here, we present a concept mission that will offer sensitive measurements for frequencies below 20 MHz to 300 kHz. This frequency band will probe the redshifted 21 cm cosmological signal from the early universe from around 0.38 to 400 million years after the Big Bang.

keywords:

Radio Cosmology, Deep Field, High Dynamic Range Imaging, Direction Dependent Calibration

In-person or online?:

in-person

Career level:

Mid-Senior

Techniques / **3**

Radio Galaxy Zoo: EMU - paving the way for EMU cataloguing

Authors: Hongming Tang[1]; Eleni Vardoulaki[None]

[1] *Department of Astronomy, Tsinghua University*

The Evolutionary Map of the Universe (EMU) survey is an ongoing large-scale radio continuum survey conducted by ASKAP, which will discover around 40 million radio sources. While conventional source-finding algorithms could handle ~90% of source cataloguing in EMU, there might be 4 million sources with well-extended and complex morphological structures awaited to be identified through visual inspection or reliable machine-learning methods. In this talk, I will introduce the Radio Galaxy Zoo: EMU (RGZ-EMU) citizen science project, explaining how the use of citizen science/machine learning helps to characterise the observed radio emission of these complex sources and associate them with belonging host galaxies we use multi-wavelength observations of the same sky area. Team efforts in outreach and education will also be mentioned.

keywords:

AGN, machine learning, citizen science, cross-matching, source finding

In-person or online?:

in-person

Career level:

ECR

Poster Sparklers / **15**

Radio Observations of Ram-Pressure-Stripped tails: A New Window into Galaxy Evolution

Author: Alessandro Ignesti[1]

[1] *INAF - Padova*

Deep, wide-field radio continuum observations of galaxy clusters are revealing an increasing number of spiral galaxies hosting tens of kiloparsec-long radio tails produced by the displacement of the nonthermal interstellar medium (ISM) by ram pressure. In this context, I will present a semi-empirical model for the multifrequency radio continuum emission from ram-pressure-stripped tails based on the pure synchrotron cooling of a radio plasma moving along the stripping direction with a uniform velocity. Thanks to this model, for the first time, we can indirectly measure the stripped ISM velocity, get insights into the evolution of the stripped clouds, and constrain the 3D velocity of the galaxies in the cluster.

I will showcase the results of the exploratory study on seven galaxies in Abell 2255 (z=0.08012) thanks to deep LOFAR and uGMRT observations at 144 and 400 MHz. Our model reproduces the observed properties of the ram-pressure-stripped radio tails with a projected radio plasma bulk velocity of between 160 and 430 km s^{-1}. These measurements yield the 3D velocity of the galaxies in the cluster to be 300–1300 km s^{-1}, and the estimated ram pressure affecting these galaxies to be between 0.1 and 2.9×10^{-11} erg cm^{-3}.

This semi-empirical model can be now used to expand the applications of radio observations of ram-pressure-stripped galaxies in clusters and groups, whose availability is destined to increase over the coming years with the advent of SKA. By combining deep radio, X-ray, and optical observations we will be able to quantitatively characterize the ram pressure affecting galaxies in dense environments.

[Based on Ignesti et al., 2023, A&A, Volume 675, id.A118]

keywords:

Clusters, star-forming galaxies, radio continuum

In-person or online?:

in-person

Career level:

ECR

Starbursts / Star-forming Galaxies / **29**

Radio Ring Galaxies

Author: Neda Rajabpour[1]

[1] *Western sydney university*

A new generation of radio telescopes such as ASKAP, MeerKAT and LOFAR are bringing new discoveries because of their high sensitivity to low surface brightness objects and the wide field coverage. Odd radio circles (ORC), intergalactic SNR and various other features connected with the shapes of AGN jets such as the re-collimator NGC 2663 and Dancing Ghosts are the most recent examples of such new and intriguing findings.

While searching for ORC in ASKAP and MeerKAT radio continuum images, we discovered eight radio rings (diameter < 2') associated with face-on spiral galaxies but without the central core. We named these Radio Ring Galaxies (RaRiGx). In some cases, we find that the radio emission follows the optical spiral arms which could potentially indicate either thermal or non-thermal structure connected to the HII regions or SNR activity. However, in the others we find the opposite as we can see anticorrelation which might be a product of intergalactic medium accretion or some massive central explosion. Finally, we note that the size (8-38~kpc) of our eight RaRiGx is significantly larger than the circumnuclear rings of NGC 1326 and NGC 7552 which may indicate different physical processes.

Therefore, we have an excellent sample of eight RaRiGx where at least four need different explanations from the "starburst"as their radio emission is in between galaxy optical spiral arms.

keywords:

star-forming galaxies,ring galaies, radio ring galaxies

In-person or online?:

online

Career level:

Student

Poster Sparklers / **37**

Radio continuum and HI 21-cm line emission from M51 analogs observed with SKA

Author: Masoumeh Ghasemi Nodehi[1]

Co-authors: Fatemeh Tabatabaei [2]; Elizabeth A. K. Adams [3]; Mark Sargent [4]

[1] *Xinjiang Astronomical Observatory*

[2] *Institute for Research in Fundamental Sciences, Instituto de Astrofisica de Canarias, Max-Planck-Institut fur Astronomie*

[3] *ASTRON, Kapteyn Astronomical Institute, University of Groningen*

[4] *University of Sussex, International Space Science Institute (ISSI)*

Atomic hydrogen (HI), a component of galactic gas, is essential to many astrophysical processes. In particular, mapping the HI atomic gas in and around galaxies is crucial to explore the physical conditions under which massive star formation is quenched throughout cosmic time and to analyze the feeding and feedback scenario in the traditional models of galaxy history. Sensitive SKA observations provide the first practical chance to investigate the untouched topic of HI in galaxies at higher redshifts. We simulate the HI maps of high- z galaxies whose present-day HI emission characteristics and SFR are like those of nearby galaxies such as M51. To further investigate the potential of proposed surveys in mapping HI in this galaxy at high-z, the simulations adopt the SKA configurations and sensitivities. Additionally, the study also simulates the evolution of thermal and non-thermal radio continuum (RC) emission on kpc scales within the redshift range of $0.15 < z < 3$. The objectives of this research are to examine: a) the structures of thermal and non-thermal emission on kpc scales, b) the evolution of the thermal fraction and synchrotron spectrum at mid-radio frequencies, and c) the capability of the SKA1-MID reference survey in detecting RC emitting structures.

keywords:

Simulation for SKA, HI, Radio Continuum

In-person or online?:

in-person

Career level:

ECR

Clusters/LSS / **97**

Radio-X study of CHEX-MATE radio halo clusters

Author: Marco Balboni[1]

[1] *INAF-IASF MIlan*

In this talk, I will present the first homogeneous X-ray and radio study of galaxy clusters using LOFAR, MeerKAT and CHEX-MATE XMM observations.
Past studies have shown the presence of radio-X-ray connections in galaxy clusters and used them to derive constraints on cluster energetics and particle (re-)acceleration. However, many aspects of these processes are yet to be understood. With the advent of new radio facilities at low frequencies, robust spatially resolved analyses on clusters are becoming available, providing new crucial information about different acceleration models.
As a first step of a wider systematical study, we analyzed a sample of clusters hosting radio halos, 18 observed by LoTSS and 6 in L-band by MeerKAT, drawn from the CHEX-MATE project.
I find strong correlations between X-ray and radio brightness in every target. This relation is (almost) always sub-linear, at both high and low frequencies, indicating a flatter distribution of the non-thermal component. In addition, by studying the varying radio-X relation found, for a few objects I was able to test a simplified re-acceleration model and to put constraints on some of its parameters.
Finally, for the 18 LOFAR targets, I will also present preliminary results of a tentative radio profile rescaling, as usually made for the thermal component of the ICM, searching for a universality of the halos radial profile.
In these years, a growing number of works are showing the potential of radio and X-ray synergies in galaxy cluster studies. The homogenous observations of large samples of clusters ensured by future,

deep, large surveys, such as the one made with SKA, will provide the necessary data to perform statistical and systematic analyses of these objects.

keywords:

clusters, radio-X relation

In-person or online?:

in-person

Career level:

Student

Techniques / **51**

RadioCAT: Detection Pipeline and Catalogue of Radio Galaxies in EMU Pilot Survey

Authors: Nikhel Gupta[1]; Ray Norris[1]; Andrew Hopkins[None]; Minh Huynh[None]; Zeeshan Hayder[None]

[1] *CSIRO Space & Astronomy*

We present source detection and catalogue construction pipelines to build the first catalogue of radio galaxies from the 270 deg^2 pilot survey of the Evolutionary Map of the Universe (EMU-PS) conducted with the Australian Square Kilometre Array Pathfinder (ASKAP) telescope. The detection pipeline uses Gal-DINO computer-vision networks (Gupta et al. 2023a) to predict the categories and bounding boxes for radio galaxies, as well as their corresponding infrared host galaxies. The Gal-DINO network is trained and evaluated on approximately 5,000 radio galaxies and their hosts, encompassing both compact and extended morphologies. We find that the Intersection over Union (IoU) for the predicted and ground truth bounding boxes is larger than 0.5 for 99\% of the galaxies on the evaluation set. The catalogue construction pipeline uses the predictions of the trained network on the cutouts of the radio and infrared images based on the \textit{Selavy} catalogue components. Confidence scores of the predictions are then used to prioritize \textit{Selavy} components with higher scores and incorporate them first into the catalogue. This results in a total of 211,625 radio galaxies, with 201,211 classified as compact galaxies. The remaining 10,414 are categorized as extended radio galaxies, including 582 FR-I, 5,602 FR-II, 1,494 FR-x (uncertain whether FR-I or FR-II), 2,375 R (single-peak resolved) galaxies, and 361 with peculiar morphologies. We cross-match the radio galaxies in the catalogue with the infrared and optical catalogues, finding photometric redshifts for 36\% of the galaxies. The EMU-PS catalogue and the detection pipelines presented here will be used towards constructing catalogues for the main EMU survey covering the full southern sky.

keywords:

source finding, cross-matching, machine learning, AGN

In-person or online?:

unsure

Career level:

ECR

Clusters/LSS / **39**

Re-lighting the fire in galaxy groups: the case of Hickson Compact Group (HCG) 15

Author: Christopher Riseley[1]

[1] *Alma Mater Studiorum - Università di Bologna*

While merging massive galaxy clusters are among some of the most spectacular events in the Universe, the majority of galaxies reside not in these behemoths, but in smaller structures such as poor clusters and galaxy groups. In these lower-mass environments, phenomena related to active galactic nuclei (AGN) and member galaxies play a more significant role in the enrichment and evolution of the intra-group medium (IGrM) and its associated magnetic field. However, despite the importance of studying magnetic fields in these environments, they remain largely under-explored.

Compact groups in particular represent a golden opportunity to study the effects of feedback and interactions on the IGM. These dense structures display a particular wealth of interaction-driven phenomena, from morphological peculiarities and disturbances, to AGN activity and starbursts, to shocks and group-scale outflows.

Hickson Compact Group 15 (HCG15) represents an especially unusual and enigmatic galaxy group. Dominated not by a single giant elliptical galaxy but rather six galaxies with a mixed elliptical/lenticular population, it is known to host extended thermal X-ray emission and diffuse intergalactic light but is highly deficient in neutral gas, and it also hosts an unusual diffuse radio source that has eluded classification until now.

New ASKAP observations from the EMU survey revealed that this diffuse emission is strongly polarised with a highly-ordered magnetic field, kickstarting a multi-wavelength follow-up campaign with LOFAR, the GMRT, the JVLA, and MeerKAT at S-band. In this talk, I will present the results of this campaign with a particular focus on our deep full-polarisation ASKAP and MeerKAT results. Our study sheds new light on the system, revealing the spectropolarimetric and thermal/non-thermal properties as well as the topography of the magnetoionic medium in unprecedented detail, finally allowing us to solve the mystery of HCG15's nature.

keywords:

Galaxy groups, AGN, polarisation

In-person or online?:

in-person

Career level:

ECR

VLBI / **139**

Resolving blazar jets with LOFAR-VLBI

Author: Etienne Bonnassieux[1]

[1] *JMU Wuerzburg*

Blazars are highly studied sources, as their relativistic jet being beamed towards Earth results in the Doppler-boosting of their emission above what can be detected for other AGNs. This allows them to benefit from significant observational coverage at high energies and radio frequencies, where VLBI techniques can study the evolution of components within their relativistic jets.

In the LOFAR bands, blazars (as selected from the BZCAT catalog) seem to show significantly divergent spectral properties compared to higher frequencies: specifically, they seem to diverge from

the typical blazar "flat-spectrum" and to tend towards a spectrum more characteristically associated with radio galaxies, with greater flux densities measured at lower frequencies. This is likely an indication that a new plasma population is being observed for the first time in these objects; emission which is not necessarily resolved without the international stations.

Follow-up study with LOFAR-VLBI is therefore of great interest to investigate this behaviour in more detail: does LOFAR indeed start to see new components of blazars, heretofore un-noticed? Or is it providing a new window into the properties of currently-known features of blazar jets?

keywords:

LOFAR, blazars, VLBI, LBA

In-person or online?:

in-person

Career level:

ECR

Clusters/LSS / **12**

Results from the first tier of the MERGHERS survey

Author: Kenda Knowles[1]

[1] *Rhodes University / South African Radio Astronomy Observatory*

The MeerKAT Exploration of Relics, Giant Halos, and Extragalactic Radio Sources (MERGHERS) survey is targeting a homogeneously selected sample of SZ-detected galaxy clusters with the aim of probing the cosmic and mass evolution of diffuse cluster radio emission. Almost all statistical cluster samples studied for diffuse radio emission are restricted to low-redshift, high-mass clusters due to historical telescope sensitivity limitations. MERGHERS is designed in statistically complete tiers, to build up to a large statistically significant cluster sample across wide redshift and mass ranges, as yet unprobed at mid-MHz and GHz ranges. I will present the results of the first tier of the MERGHERS project, which focuses on mid-to-high redshift clusters ($0.4 < z < 0.6$) from the Atacama Cosmology Telescope DR5 cluster catalogue, providing the first mass-selected statistical sample in this redshift range.

keywords:

clusters, diffuse emission

In-person or online?:

in-person

Career level:

Mid-Senior

Clusters/LSS / **106**

Revealing the complex shock features in the double-relic in MACS J1752.0+4440

Author: Maicol Della Chiesa[None]

Co-authors: Andrea Botteon [1]; Annalisa Bonafede [2]

[1] *INAF-IRA*

[2] *University of Bologna - Department of Physics and Astronomy*

Radio relics are extended, diffuse radio sources tracing particle (re-)acceleration due to ICM shock waves in merging galaxy clusters. Characterized by elongated arc-shapes, they are typically found in cluster outskirts, with sizes ranging from 0.5 to 2 Mpc, highly polarized emission (up to $\sim 60\%$) and brightness profiles decreasing toward the cluster center. MACS J1752.0+4440 hosts a double-relic system, a phenomena in which two radio relics form from a single merging event and whose observability is aided by the shock happening near the plane of the sky. The NE relic shows a peculiar morphology, with two parallel filaments possibly tracing a double shock front.
In my talk, I will report on results from the spectral and curvature analysis of the two radio relics, using LOFAR (144MHz), new uGMRT (416MHz and 650MHz) and archival VLA (1.6GHz) radio data. The high resolution of the instruments, allowed us to detect substructures along the NE relic main axis. Surprisingly, we measured spectral indexes for the two relics that are flatter than those predicted by the DSA theory. Furthermore, the newly produced color-color plots and the spectral curvature map show evidence for concave spectra, in opposition with spectral aging models. The combinations of all these results suggests that strong projection effects are in action. This is also supported by depolarization observed in the two relics observed with the VLA.
Despite that double radio relic clusters are usually considered as systems where projection effects are minimized, our results on MACS J1752 demonstrate that caution is needed even in the interpretation of these only apparently simple systems.

keywords:

galaxies; clusters; intracluster medium; non-thermal; radio continuum; shock waves; polarisation; radio relics;

In-person or online?:

in-person

Career level:

Student

VLBI & Cosmology / 71

Searching for Radio-Loud Gravitational Lenses in VLASS

Author: Michael Martinez[1]

[1] *University of Wisconsin - Madison*

Gravitational lensing provides a powerful tool for studying the nature of dark matter given its sensitivity to any mass along the lensing line of sight. Dark subhalos with no luminous stellar component cause astrometric and photometric anomalies, which can be observed given sufficient angular resolution. While these observations are possible with Very Long Baseline Interferometry (VLBI), the number of lensed radio sources is orders of magnitude lower than the total number of lenses, with only about 50 currently known.

In this talk, I present the results of a pilot project to discover new radio-loud gravitationally lensed sources. Using Very Large Array (VLA) follow-up to VLA Sky Survey (VLASS) selected lens candidates, I report 5 new radio-loud gravitational lenses, a 10% increase in the present sample size. I will also discuss plans for future observations in which we expect to further extend this sample by 50%, laying the groundwork for a statistically robust VLBI program to provide new constraints on dark

matter. Finally, I discuss the applicability of this type of program to the observatories of the future, including SKA-1 and ngVLA.

keywords:

cosmology, surveys, AGN, gravitational lensing

In-person or online?:

unsure

Career level:

Student

Galactic & AGN/ High-z / 102

Searching for Young Radio AGN via Broadband Radio Spectral Analysis

Authors: Pallavi Patil[1]; Mark Whittle[2]; Kristina Nyland[3]; Carol Lonsdale[4]; Mark Lacy[4]; Amy Kimball[4]; Colin Lonsdale[5]

[1] *Johns Hopkins University*

[2] *University of Virginia*

[3] *Naval Research Laboratory*

[4] *NRAO*

[5] *MIT Haystack Observatory*

Most massive galaxies are now thought to go through an Active Galactic Nucleus (AGN) phase one or more times. Yet, the cause of triggering and the variations in the intrinsic and observed properties of the AGN population are still poorly understood. Young, compact radio sources associated with accreting supermassive black holes represent an essential phase in the life cycles of jetted AGN for understanding AGN triggering and duty cycles. They exhibit compact radio morphologies (<10 kpc) and spectral turnover within 100 MHz to a few GHz frequencies. The superb sensitivity and broadband frequency coverage of new and upcoming radio continuum surveys have opened up a phase space to identify compact and peaked radio sources across a wide range of redshifts and luminosities. In this talk, we present radio spectra modeling of a sample of young radio AGN selected by cross-matching WISE and NVSS catalogs. Our sample galaxies are believed to be in a unique evolutionary stage just after the (re)ignition of the radio AGN, while the host galaxy is still experiencing substantial starburst activity. The radio spectra presented here are carefully constructed from our own 10 GHz observations and archival radio survey data, including VLASS, NVSS, RACS, LOTSS, TGSS, and other radio sky surveys. They together yield 6-11 flux density measurements spanning 0.1-10 GHz frequencies. Our analysis shows that 63% of the sample exhibit either peaked or curved radio spectra, and 37% are classified as Gigahertz Peaked Spectrum (GPS) sources. Peaked spectra strongly indicate compact emission regions likely arising from recently triggered radio jets. I further explore the implications of different absorption mechanisms on the physical conditions and properties of these sources. Overall, this study provides a foundation for combining multi-frequency and mixed-resolution radio survey data for understanding the impact of young radio jets on the ISM and star formation rates of their host galaxies.

keywords:

AGN, cross-matching, radio-spectra, jetted AGN, radio continuum surveys

In-person or online?:

in-person

Career level:

ECR

Poster Sparklers / **76**

Serendipitous Discovery of 100 kpc Twin Jets in a Peculiar S-Shaped Radio Galaxy

Authors: Sagar Sethi[1]; Marek Jamrozy[1]; Agnieszka Kuzmicz[1]

[1] *Jagiellonian University*

We report the disclosure of an S-shape morphology of a giant radio galaxy (GRG) revealed in dedicated low-frequency observations from uGMRT and LOFAR. This GRG is powered by a billion solar mass black hole from which the vicinity of well-collimated, slender twin radio jets span ~ 100 kpc. These jets can be considered as "naked jets" due to the absence of detectable diffuse radio cocoons, and remain conspicuous even at lower radio frequencies. In contrast, the outer radio configuration exhibits hotspots and diffuse lobes oriented almost perpendicular to the jet axis. The entire radio structure, likely due to systematic jet precession, is less than 50 Myr old, has a power of ~6E24 W/Hz at 1.4 GHz, and morphologically is neither pure FR I nor FR II type. The combination of FR-II type morphology with the twin naked jets is unusual and, together with the overall S-shaped structure of this source, provides an excellent opportunity to address the intriguing problem of S-shaped RGs in general and characterize in great detail the twin kpc scale jets in GRGs.

keywords:

galaxies: active galaxies: jets - galaxies: radio galaxies - galaxies: radio-jet

In-person or online?:

in-person

Career level:

Student

Clusters/LSS & AGN/High-z / **33**

Source dynamics and evolution of low-luminosity FRII radio galaxies

Author: Bonny Barkus[1]

[1] *Open University*

I will present new VLA observations that reveal the structure of a new population of low-luminosity FRII radio galaxies discovered in LoTSS. Fanaroff and Riley (1974) identified a luminosity break between their two morphological classes. FRIs are defined to be low-luminosity, centre bright jets and the higher luminosity FRIIs have jets that are edge brightened and terminate in hotspots. Using LoTSS DR1, Mingo et al (2019) demonstrated an overlap in luminosity between FRI and FRII morphology rather than a clear divide, discovering a sub-sample of FRIIs with luminosities up to 3 magnitudes lower than the typical FR break. A population of low-luminosity FRIIs raises questions about their origins; are they older, fading FRIIs, or hosted by lower mass galaxies? Our new VLA observations of a sample of LoTSS-selected low-luminosity FRIIs allow us to make comparisons between the two FRII luminosity populations on the prevalence of hotspots, as well as morphological and spectral differences.

keywords:

AGN, Galaxy Morphology

In-person or online?:

online

Career level:

ECR

Techniques / **96**

Stacking radio stars in MIGHTEE

Author: Francesco Cavallaro[1]

[1] *INAF-OACt*

The MIGHTEE (MeerKAT International GHz Tiered Extragalactic Exploration) survey has emerged as a groundbreaking initiative, leveraging the unprecedented capabilities of the MeerKAT radio telescope array to explore the depths of the radio sky. Even if its primary focus is on extragalactic sources, MIGHTEE can push forward the study of late-type stars through stacking techniques. .

Stars, typically associated with optical and infrared observations, have been relatively unexplored in the radio wavelength domain. MIGHTEE's unique sensitivity and high-resolution imaging provide an opportunity to revolutionize our understanding of stellar radio emission. By employing the innovative technique of stacking, we aggregate faint signals from individual stars, thereby enhancing our ability to detect and characterize the radio emission from this stellar population.

The presentation will outline the methodology behind the stacking process, highlighting the challenges and advantages associated with probing the radio properties of stars in large-scale surveys. Preliminary results from the MIGHTEE survey will be presented, showcasing the collective radio signatures of stacked stars and providing insights into the underlying physical mechanisms responsible for their radio emission.

keywords:

radio stars, stacking, polarisation, survey

In-person or online?:

in-person

Career level:

Mid-Senior

VLBI / **62**

Strap on your Boötes: The Journey to Achieve Widefield Sub-arcsecond Resolution with LOFAR

Authors: Emmy Escott[1]; Leah Morabito[2]

[1] *Durham University*

[2] *Durham*

Recent technological developments have allowed radio surveys to go deeper than ever before. One such example is the International LOFAR Telescope (ILT). With the first data release of the LOFAR Two-meter Sky Survey (LoTSS) Deep Fields, we have access to 6”radio images at 144 MHz with sensitivities down to 20 μJy/beam, which was previously unprecedented at such low frequencies. This is just the tip of the iceberg to what can be achieved using the ILT. The current Deep Fields data release uses only the Dutch stations, despite having data recorded from the international stations. By incorporating the international stations, we can improve the resolution by a factor of 20 moving down to sub-arcsecond resolution, all the way to 0.3”.

With the publicly available pipeline (Morabito et al. 2022), it is becoming more common to produce these sub-arcsecond resolution images of individual sources. It is also possible to produce a widefield image at this resolution covering the whole field of view and containing thousands of sources, but this technique is challenging. To date, there is only one fully imaged field, the Lockman Hole, at sub-arcsecond resolution in the literature (Sweijen et al. 2022).

In this talk, I will discuss the challenges that are faced when producing a widefield high resolution image with the ILT. This includes having to correct for differential ionospheric effects across multiple square degrees and starting self-calibration without knowing the source structure. I will present the first sub-arcsecond image of Boötes to demonstrate the scientific potential of such widefield high resolution images.

keywords:

LOFAR, HIgh Resolution, Deep Fields, Sub-Arcsecond, Radio Imaging

In-person or online?:

in-person

Career level:

Student

VLBI & Cosmology / 31

Strong lensing by galaxies with the SKA

Author: Alessandro Sonnenfeld[1]

[1] *Shanghai Jiao Tong University*

Strong gravitational lensing offers one of the cleanest means for measuring masses at cosmological distances. This allows to address important questions related to the efficiency of star formation in galaxies and the nature of dark matter. Optical surveys such as Euclid are expected to discover tens of thousands of galaxy-scale lenses, opening up the age of statistical strong lensing. However, the analysis of optical strong lensing data is complicated by the contamination from the foreground galaxy. Strongly lensed radio sources offer unique advantages over their optical counterparts: they have a better-defined selection function and they allow for the detection of images very close to the centre of the lens. This in turn makes it possible to make more accurate inferences, probe lower galaxy masses, and put constraints on the central black hole mass function. I will discuss the opportunities offered by the SKA for strong lensing science and the associated challenges.

keywords:

imaging, source finding, AGN, massive galaxies

In-person or online?:

in-person

Career level:

Mid-Senior

Galactic / **67**

The Crab Nebula with the LOFAR Long Baselines

Authors: Maria Arias[None]; Roland Timmerman[1]

[1] *Durham University*

The Crab Nebula, the pulsar wind nebula surrounding the Crab pulsar, is one of the most thoroughly studied objects in the sky. In this talk, I will present a subarcsecond resolution image of the nebula at 150 MHz, which is possibly the highest dynamic range image ever made with LOFAR. The new observations allow us to measure the expansion of the pulsar wind nebula, which resulted from a supernova explosion in 1054. Our map further shows new absorption features that can shed light on the magnetic field properties of the nebula.

keywords:

ILT, Milky Way, supernova remnants, pulsar wind nebulae

In-person or online?:

in-person

Career level:

ECR

Surveys / **7**

The Evolutionary Map of the Universe

Author: Andrew Hopkins[1]

[1] *Macquarie University*

EMU, the Evolutionary Map of the Universe, is an ongoing ASKAP survey of the southern hemisphere, delivering 943 MHz continuum images with rms noise of about 20 microJy/beam at 15 arcsec resolution. EMU is supporting a broad range of science, spanning star formation and evolution in our own Galaxy, galaxy evolution and the links between star formation and supermassive black holes, to cosmology. EMU will be the touchstone radio continuum survey in the south for the foreseeable future. EMU provides an ideal resource for defining galaxy samples to understand the link between gas fuelling and both AGN and star formation processes, as each are intimately associated with the radio continuum. Moreover, given the overlap with the WALLABY HI ASKAP survey, neutral gas information will also be available for a significant fraction of low-redshift EMU sources. I will summarise the current status of EMU, how to access and use the data and how get involved in the project.

keywords:

Survey overview, science updates, cross-team collaboration

In-person or online?:

online

Career level:

Mid-Senior

Poster Sparklers / **137**

The GRACE project: high-energy giant radio galaxies and their duty cycle

Author: Gabriele Bruni[1]

Co-author: Francesca Panessa [2]

[1] *INAF - Institute for Astrophysics and Planetology from Space*

[2] *IAPS-INAF*

The advent of new generation radio telescopes is opening new possibilities on the classification and study of extragalactic high-energy sources, specially the underrepresented ones like radio galaxies. Among these, Giant Radio Galaxies (GRG, larger than 0.7 Mpc) are among the most extreme manifestations of the accretion/ ejection processes on supermassive black holes. Our recent studies have shown that GRG can be up to four times more abundant in hard X-ray selected (i.e. from INTEGRAL/IBIS and Swift/BAT at >20 keV) samples and, most interestingly, the majority of them present signs of restarted radio activity. This makes them the ideal testbed to study the so far unknown duty cycle of jets in active galactic nuclei. Open questions in the field include: How and when jets are restarted? How jets evolve and what's their dynamic? What is the jet's duty cycle and what triggers them? Our group has recently collected a wealth of radio data on these high-energy selected GRGs, allowing us to study their jet formation and evolution from the pc to kpc scales, across different activity epochs. Furthermore, we are devoting an effort to the exploitation of new radio surveys data for the discovery of new classes of counterparts of Fermi/LAT and ANTARES catalogues. In particular, we are unveiling the hidden population of radio galaxies associated with gamma-ray sources, and possibly with neutrino events.

keywords:

cross-matching, AGN, jets duty cycle, high-energy emission

In-person or online?:

in-person

Career level:

Mid-Senior

Poster Sparklers / **56**

The GaLactic and Extragalactic All-sky MWA Survey at 300 MHz

Author: Stefan Duchesne[1]

[1] *International Centre for Radio Astronomy Research - Curtin University*

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

keywords:

survey overview

In-person or online?:

in-person

Career level:

ECR

Surveys / **40**

The LeMMINGs survey: probing sub-kpc radio structures of nearby galaxies with e-MERLIN

Author: Ranieri D. Baldi[1]

[1] *INAF-IRA*

The Legacy e-MERLIN Multi-band Imaging of Nearby Galaxies survey (LeMMINGs) is a statistically-complete census of nuclear accretion and star formation processes in the local Universe in active and not active galaxies. The LeMMINGs observations at 1.5 and 5 GHz yield angular resolutions on 10s milliarcsecond-scales, with sensitivities of 10s μJy. Awarded 810 hours of observing time, the full statistical sample (at 1.5 GHz) plus several studies of individual objects have now been published. Combined with multi-wavelength follow-up observations, this survey will provide a unique legacy data set of our Galactic back yard, a springboard for the forthcoming SKA surveys. I will present an overview of the LeMMINGs results so far, including the 1.5 GHz sample results and associated Chandra X-ray data and optical HST data. I will describe the next steps for LeMMINGs to analyse the 5 GHz survey and produce widefield images to categories all radio sources in the LeMMINGs galaxies.

keywords:

local galaxies, active and non-active galaxies, AGN, jets, star formation

In-person or online?:

in-person

Career level:

Mid-Senior

Surveys / **122**

The MIGHTEE continuum survey: cross-matching, source classification and science results

Authors: Imogen Whittam[1]; Catherine Hale[2]; Matt Jarvis[3]; Ian Heywood[2]

[1] *University of Oxford / University of the Western Cape*

[2] *University of Oxford*

[3] *Oxford University / University of the Western Cape*

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 ~2 uJy 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 will describe recent work identifying multi-wavelength counterparts for the sources detected in MIGHTEE Early Science data (Whittam et al., 2024) and provide an update on the work currently in progress cross-matching the full MIGHTEE survey. I will then outline the methods used to classify the MIGHTEE sources into different source types (e.g. AGN, SFG) using the extensive multi-wavelength information available, and the insights this gives us into the nature of the faint radio source population (Whittam et al., 2022).
Finally, I will highlight some recent science results from the MIGHTEE continuum survey. This will include the properties of the radio galaxies in the field; in particular, I will discuss whether or not there is evidence for a dichotomy in the accretion rates of high-excitation and low-excitation radio galaxies, and the implications this has for the role radio galaxies play in galaxy evolution.

keywords:

survey overview, cross-matching, AGN, radio galaxies, source classification

In-person or online?:

online

Career level:

ECR

Surveys / **103**

The MPIfR MeerKAT Galactic Plane Survey (MMGPS)

Author: Akriti Sinha[1]

[1] *Indian Institute of Technology Indore*

On behalf of the MMGPS team, I will present preliminary results from the ongoing 3000-h MPIfR MeerKAT Galactic Plane Survey being performed at L and S bands. The survey provides high-fidelity maps at ~ 20μJy/beam with 5-20′′ resolution. Due to the dense array configuration of MeerKAT and sensitivity towards low surface brightness diffuse emission, we detect a plethora of extended structures. When completed, the survey will produce an unprecedented rotation measure (RM) grid that will be sensitive to |RM| up to 2 × 10^4 rad/m2 with an accuracy of ~ 15 rad/m2, and Faraday depth structures extended up to 280 rad/m2. The data products from the MMGPS, comprising of maps of total intensity, spectral index, polarized intensity, and Faraday depth, will provide a detailed view of the thermal and nonthermal emission processes of the extended diffuse emission, filamentary structures and the 3D magnetic field structures in the turbulent Galactic plane. This will enable us to investigate a diverse array of astrophysical phenomena, encompassing supernova remnants, molecular gas, HII regions, star-forming complexes and non-thermal filaments.

keywords:

Galactic plane survey, star-forming

In-person or online?:

in-person

Career level:

ECR

Surveys / **80**

The MeerKAT S-band: early science on the DEEP2 field and prospects for MeerKAT+

Author: Shilpa Ranchod[1]

[1] *Max Planck Institute for Radio Astronomy*

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"x3.2"(5.0"x2.2") and a combined image sensitivity of 4.5 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.

keywords:

Imaging, source counts, survey overview

In-person or online?:

in-person

Career level:

Student

Surveys & Clusters/Lss / **13**

The MeerKAT View of the Shapley Supercluster: Calibration, Imaging and Mosaicing

Author: Keegan Trehaeven[1]

Co-authors: Oleg Smirnov [2]; Tiziana Venturi Venturi [3]

[1] *Rhodes University*

[2] *Rhodes University & SKA SA*

[3] *INAF, Istituto di Radioastronomia*

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 $\sim 3^\circ$ on the sky and was recently observed by MeerKAT (L-band) and ASKAP (being a POSSUM Pilot2 target). It contains 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. New uGMRT Band-3 observations show a partial detection of the bridge and allow us to perform a preliminary spectral study and confirm the presence of very mild ongoing in-situ particle (re)-acceleration. However, tracing the merger history of this exciting region in detail with robust spectral index and ageing maps requires ultra-deep continuum images of uniform sensitivity across the entire complex. Hence, in anticipation for up-coming follow-up MeerKAT UHF-Band observations, we demonstrate using DDFacet and other radio interferometric data reduction software a novel technique of visibility-plane primary-beam-corrected mosaicing up, including direction-dependent calibration and point source subtraction. 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.

keywords:

imaging, calibration, mosaicing, extragalactic, continuum, galaxy clusters

In-person or online?:

in-person

Career level:

Student

Clusters/LSS / **100**

The Planck clusters in the LOFAR sky: latest statistical results

Author: Virginia Cuciti[1]

[1] *UNIBO*

Many galaxy clusters show diffuse cluster-scale emission in the form of radio halos and relics, showing that magnetic fields and relativistic electrons are mixed in with the intracluster medium (ICM). Although there is broad consensus that the formation of these sources is connected to turbulence and shocks in the ICM, the details of particle acceleration, magnetic field and sources of highly energetic particles are still poorly known. Statistical studies of large samples of galaxy clusters have the potential to unveil the connection of these sources with the cluster mass and formation history. However, previous studies where limited by the observing frequency and sensitivity of radio observations to the most massive clusters and therefore they where based on a small number of radio diffuse sources. LOFAR has allowed us to overcome these limitations. We analysed the low-frequency (140 MHz) radio emission from all 309 clusters in the second catalog of Planck Sunyaev Zel'dovich detected sources that lie within the 5634 deg^2 covered by the Second Data Release of the LOFAR Two-meter Sky Survey (LoTSS-DR2). We found 83 clusters that host a radio halo and 26 that host one or more radio relics. We derived upper limits to the diffuse emission of clusters without radio halos. The majority of the clusters of the sample have available X-ray data, which we analysed to derive their dynamical status. We studied the occurrence of radio halos as a function of cluster mass, redshift and dynamics. We derived the correlation between radio power and host cluster mass, and investigated the distribution of clusters without radio halos with respect to this correlation. We studied the occurrence of radio relics and their scaling relations. In this talk I will show the main

results of this project, which not only allowed us to build the largest sample of clusters with homogenous observations available to date, but it also represents an important preparatory work in view of the statistical studies that will be possible with the SKA surveys.

keywords:

galaxy clusters, LOFAR, diffuse emission, statistics

In-person or online?:

in-person

Career level:

Mid-Senior

Surveys / 55

The Rapid ASKAP Continuum Survey

Author: Stefan Duchesne[1]

[1] *International Centre for Radio Astronomy Research - Curtin University*

Surveys of the sky at multiple wavelengths provide a complete view into the large-scale properties of the Universe while also allowing studies of individual and also unique and heretofore unknown astrophysical objects and processes. The Australian SKA Pathfinder (ASKAP) is completing a series of shallow radio-frequency surveys as part of the Rapid ASKAP Continuum Survey" (RACS). RACS covers three radio-frequency bands centred on 888, 1367, and 1655 MHz and covers the sky up to declination ~+49 degrees. RACS provides a combination of frequency, sensitivity (~ 150-300 micro-Jansky per beam), and resolution (~8-15 arcsec) that fills a niche in the existing ecosystem of widefield surveys. Imaging and catalogue releases are underway and focus on the Stokes I and V continuum emission of the sky accessible to ASKAP, featuring 2-3M radio sources in each of the three bands. As well as this continuum component, spectro-polarimetric work in Stokes Q and U is also underway. On behalf of the team behind RACS, I will describe the surveys, highlight a selection of science results so far, and report on the current and upcoming releases and progress of RACS.

keywords:

survey overview

In-person or online?:

in-person

Career level:

ECR

Galactic / 126

The SKA precursor view of Galactic extended sources

Author: Filomena Bufano[1]

[1] *INAF-OACT*

Deep radio continuum surveys are an essential tool for the study of the different populations of Galactic radio-emitting objects. So far, however, statistical studies of these families are severely affected by selection effects due to the limited capabilities of existing surveys, which undermine the detection of the shallowest and most extended sources. This observational bias results in an underestimation of the studied populations with respect to the theoretical predictions.
In this context, ASKAP and MeerKAT, thanks to their high sensitivity, resolution and uv-coverage, come to fill this gap. These instruments are capable of producing complete censuses of Galactic radio-emitting objects, allowing for their detailed characterization, and revolutionizing stellar astrophysics.
In this talk, we will present the results obtained with data from the MeerKAT SARAO Galactic Plane Survey and the ASKAP Evolutionary Map of the Universe. We will introduce a statistical analysis of the more than 15k extended sources detected in the MeerKAT tiles (l=2-60°, 252-358°, b=+-1.5°). We will discuss the implications for the study of Galactic HII regions, evolved stars and supernova remnants, as well as for the identification of unknown sources. Then, we will focus on the study of Galactic SNRs, which are among the most extended sources in the Galactic plane. We will show some interesting cases found in a sample of 28 known SNRs, for which we could produce integrated and spatially resolved spectra combining SGPS and MWA data, providing deeper insights into their morphology and physics. Finally, we will present new SNRs from the ASKAP EMU survey, highlighting the potential of SKA precursors for the discovery of candidate objects.

keywords:

MilkyWay, Supernova remnants, MeerKAT, ASKAP

In-person or online?:

unsure

Career level:

Mid-Senior

Clusters/LSS & AGN/High-z / 143

The VLA Sky Survey (VLASS)

Surveys & Clusters/Lss / 98

The ViCTORIA project: a multi-frequency radio survey of the Virgo galaxy cluster

Authors: Francesco de Gasperin[1]; Henrik Edler[2]

[1] *IRA INAF*

[2] *University of Hamburg*

The ViCTORIA (Virgo Cluster multi-Telescope Observations in Radio of Interacting galaxies and AGN) project includes three large radio surveys made with LOFAR LBA, LOFAR HBA and MeerKAT. The surveys' footprint extends over the virial radius of the Virgo cluster and covers the most relevant sub-clusters. This project will deliver: images at GHz frequencies of our closest rich galaxy cluster 60 times deeper than existing data, in full polarisation, and including a blind HI survey that aims at mapping seven times more galaxies than previous experiments and without selection biases. The main scientific goal is to use Virgo as a test bed for galaxy evolution and AGN-ambient interaction.

In this talk, I will present the release of the LOFAR HBA data and a will show preliminary results from LOFAR LBA and MeerKAT data. Then, I will discuss the radio emission coming from AGN that are part of the cluster, discussing possible scaling relations and their link to the cluster environment. Specifically, I will show the newly discovered emission from two faint and very steep spectrum radio galaxies (M49 and NGC4365). Finally, we will present the analysis of the radio lobes structures in the central radio galaxy M87 at the highest resolution to date.

keywords:

radio surveys, galaxy clusters, AGN

In-person or online?:

in-person

Career level:

Mid-Senior

Surveys / 52

The continuum science pathfinder experiment for the SKA, a.k.a. the superMIGHTEE project

Authors: Dharam Lal[1]; Russ Taylor[2]; Srikrishna Sekhar[3]; C.H. Ishwara-Chandra[4]

[1] *National Centre for Radio Astrophysics - Tata Institute of Fundamental Research*

[2] *University of Calgary*

[3] *National Radio Astronomy Observatory*

[4] *National Centre for Radio Astrophysics TIFR*

The MeerKAT International GHz Tiered Extragalactic Exploration (MIGHTEE) is one of eight approved Large Survey Projects on the MeerKAT Square Kilometre Array (SKA) precursor telescope. It has devoted nearly 2000 hours of MeerKAT time over several years to secure deep imaging at 2 micro-Jy sensitivity covering 20 sq. deg. over a bandwidth of 0.9-1.6 GHz. Alongside, the upgraded Giant Metrewave Radio Telescope SKA pathfinder telescope offers the matching imaging angular resolution and sensitivity between 250-850 MHz as the MeerKAT MIGHTEE project. Thus, this ultra-broad data, 250-1600 MHz from two major facilities not only has tremendous scientific potential for the MIGHTEE deep fields, i.e., it provides extraordinary opportunities to study and characterise the deep radio sky, but also presents us with several technical challenges that must be addressed for the wide-band surveys with the SKA. We will summarise this continuum science pathfinder for the SKA, a.k.a. the superMIGHTEE project, present early results from it. More specifically, we will show that the scientific output of it will have a profound impact on our understanding of several science drivers, e.g., (i) the evolution of active galactic nuclei and star-forming galaxies over cosmic time as functions of stellar mass and environment; (ii) the evolution of neutral hydrogen; (iii) the evolution of cosmic magnetic fields in galaxies, groups of galaxies and clusters of galaxies.

keywords:

deep fields, survey, imaging, calibration, RFI, clusters, AGN, polarisation

In-person or online?:

unsure

Career level:

Mid-Senior

Surveys & Clusters/Lss / **72**

The head-tail radio galaxy and revived fossil plasma in Abell 1775

Authors: Ardiana Bushi[1]; Daniele Dallacasa[2]; Andrea Botteon[3]

[1] *University of Bologna*

[2] *University of Bologna, Astronomy Dept.*

[3] *INAF-IRA*

Head-tail radio galaxies in clusters exhibit distinctive features where the head corresponds to an elliptical galaxy and two radio jets/tails sweep back from the head forming an extended structure behind the radio galaxy, that is moving through the intracluster medium (ICM). This morphology arises when the magnetized relativistic plasma outflowing from the host/parent galaxy is deflected and decelerated by ICM. In contrast, revived fossil plasma trace active galactic nucleus (AGN) radio plasma with a very steep spectrum that has somehow been re-energized through processes in the ICM, unrelated to the target radio galaxy itself.

In this talk, I will report on new results of a LOFAR-uGMRT analysis of the head-tail radio galaxy and revived fossil plasma in Abell 1775.

By combining LOFAR data at 144 MHz with the new follow-up observations carried out with the uGMRT at 400 and 650 MHz, we characterize the spectral properties along the tail. From the radio color-color analysis, we found evidence for particle re-acceleration in the outer region of the tail. In general, we observed a decrease of the estimated equipartition magnetic field, luminosity, and minimum pressure as moving farther from the head along the tail.

Thanks to the new highly sensitive and high-resolution images, we recovered the structure of the revived fossil plasma, which appears as thin filaments with ultra-steep spectra of > 2.

Overall, this work demonstrates the crucial role of multi-band low-frequency observations for the study of non-thermal phenomena in galaxy clusters.

keywords:

Galaxy clusters, radio galaxies, diffuse radio emission, non-thermal emission, acceleration of particles, intracluster medium.

In-person or online?:

in-person

Career level:

Student

Poster Sparklers / **144**

The interplay between relativistic plasma and thermal gas in a galaxy group

Thanks to the continuous improvement in capabilities of the instrumentation it is now possible to probe the non-thermal phenomena occurring in galaxy groups, which are still poorly explored systems with respect to massive galaxy clusters in the radio regime.
In this project we present the NGC7618/UGC12491 major group merger that has been intensively studied in the X-rays, showing a series of complex features, but that still lacks a detailed radio investigation. Our focus is thus to complement the X-rays with a multi-frequency study using data

obtained from LOFAR at 144 MHz, GMRT at 323 and 608 MHz and JVLA in L band.
Preliminary images show the presence of diffuse radio emission at the center of NGC7618, whose nature is ambiguous. A likely scenario is that the emission comes from material ejected by the central AGN and then distributed by sloshing motions.
The aim of the work is to shed light on the origin of this source by combining the X-rays and radio observations.

Clusters/LSS / **9**

The magnetised intergalactic medium revealed by ASKAP and LOFAR

Author: Shane O'Sullivan[1]

[1] *Universidad Complutense de Madrid*

Using broadband radio polarimetry we can probe regions of diffuse ionised and magnetised gas that are challenging to detect by other means, such as in the halos of galaxies (CGM), galaxy clusters (ICM), and filaments of the cosmic web (ie. WHIM). Here I will highlight recent results from the LOFAR and ASKAP radio telescopes, that use the effect of Faraday rotation to illuminate the CGM, ICM and WHIM gas. In particular, I will present the latest progress of the LOFAR Two Metre Sky Survey (LoTSS) Faraday rotation measure grid, and provide some early results from the ASKAP-POSSUM survey. As the quality and quantity of the radio data improves, we can combine it with other tracers of cosmic structure in order to better understand the role this diffuse magnetised gas plays in the evolution of galaxies and the cosmic web in general.

keywords:

cosmic web, magnetic fields, polarisation, Faraday rotation

In-person or online?:

in-person

Career level:

Mid-Senior

Galactic & AGN/ High-z / **57**

The most extreme z>5 AGN uncovered by RACS

Author: Luca Ighina[1]

[1] *INAF-Brera*

In this talk I will present what is now the largest statistically complete sample of $z > 5$ radio-powerful AGN currently available. The sample was built starting from the RACS radio survey and its combination with the deepest wide-area optical/NIR survey. It is composed by 32 high-z objects, 15 of which newly discovered by us through dedicated spectroscopic observations. I will also present several application of this sample in different contexts: from statistical studies of the whole sample, aimed at constraining the evolution of these sources in the primordial Universe as well as the degree of obscuration in theses high-z systems, to the detailed multi-wavelength study of individual sources, aimed at constraining the properties of the jets and SMBHs hosted in these extreme systems. Finally, I will also show how future radio surveys performed by SKA and its precursors will allow us to push these studies to unprecedented redshifts.

keywords:

AGN, high-z, survey, multi-wavelength

In-person or online?:

in-person

Career level:

Student

Galactic & AGN/ High-z / 35

The nature of compact radio-loud AGN: a systematic look at the LOFAR AGN population

Authors: Jones Chilufya[1]; Martin Hardcastle[1]; Jonathon Pierce[1]; Judith Croston[2]; Beatriz Mingo[2]; Xuechen Zheng[3]; Ranieri Baldi[4]; Huub Röttgering[3]

[1] *University of Hertfordshire*

[2] *The Open University*

[3] *Leiden University*

[4] *INAF - Instituto di Radioastronomia*

The advent of long-baseline interferometers such as the LOw-Frequency Array (LOFAR) telescope enables high angular resolution and sensitivity, which is crucial for understanding synchrotron emission processes and the low-frequency spectral behaviour of radio-loud active galactic nuclei (RLAGN). Using the large RLAGN sample constructed from the LOFAR Two-metre Sky Survey (LoTSS) first data release, we have selected 55 candidates of unresolved high-excitation radio galaxies to investigate the nature of an emerging population of low-luminosity compact RLAGN numerically dominating the local Universe on sub-kpc scales. These objects are unresolved at 6 arcsec angular resolution at 150 MHz. We use high-frequency 6 GHz Very Large Array (VLA) observations of these sources to resolve them on the sub-kpc scale. We show that many of these objects remain compact at 0.3 arcsec angular resolution, which corresponds to an upper limit of less than 1 kpc in physical size, whereas a small fraction of sources shows sub-kpc extended radio emission. The latter exhibit varied radio morphologies including double-lobed, one-sided, and two-sided structures. The radio spectra of our sample computed between 150 MHz and 6 GHz range from steep to flat/inverted and span the range seen for various sources such as compact symmetric objects, compact steep-spectrum sources, and gigahertz-peaked spectrum sources. We investigate the environments in and around these compact objects using synchrotron self-absorption and free-free absorption models and find that the former is the likely explanation of the spectral turnover observed in some sources at 150 MHz. Using the power/linear size diagram, we speculate that our objects, in terms of luminosity, could represent a continuity between Seyferts and radio-quiet quasars in AGN unified models. A comparison with so-called FR0 sources indicate that they could be drawn from the same spectral index distribution and share similar radio-powers and morphologies.

keywords:

galaxies: jets – galaxies: active – radio continuum: galaxies

In-person or online?:

in-person

Career level:

Student

Surveys & Clusters/Lss / 5

The sub-uJy radio sky at sub-arcsecond resolution: lessons learned from VLA extragalactic radio surveys

Author: Eric Faustino Jiménez Andrade[1]

[1] *Institute of Radio Astronomy and Astrophysics - National Autonomous University of Mexico*

Radio continuum imaging has been a key approach to trace the production of stars and the activity of supermassive black holes at redshifts 0 < z < 5 –a cosmic epoch marked by the dominant fraction of star formation that is obscured by dust. In recent years, our team has pushed the resolution and sensitivity limits of the Very Large Array (VLA) to obtain some of the deepest and sharpest radio continuum images ever obtained, providing unique constraints on the radio morphologies of massive star-forming galaxies at high redshifts. In this talk, I will present updates on the multi-frequency VLA radio surveys in the GOODS-N, Frontier, and CEERS fields that reach sub-uJy sensitivity and sub-arcsecond resolution at 3-10GHz. After summarizing the available data products and initial science results, the talk will focus on the imaging challenges faced to produce and characterize the aforementioned radio surveys. In particular, I will present an empirical analysis that explores different imaging algorithms to minimize the total fraction of spurious sources in deep, high-resolution radio continuum maps, which will be key to explore future SKA and ngVLA blind radio surveys.

keywords:

survey overview, imaging, star-forming galaxies

In-person or online?:

in-person

Career level:

ECR

Galactic & AGN/ High-z / 16

The variability of nearby stellar sources in LoTSS

Authors: Cyril Tasse[1]; Martin Hardcastle[2]; Philippe ZARKA[3]; Timothy Shimwell[4]; Joseph Callingham[5]; Harish Vedantham[6]; Alan Loh[1]

[1] *Observatoire de Paris*

[2] *University of Hertfordshire*

[3] *CNRS - Observatoire de Paris*

[4] *Leiden University*

[5] *ASTRON*

[6] *Kapteyn Astronomical Institute*

The LOFAR Two-meter Sky Survey is the largest extragalactic survey to date. As part of the final stages of our third generation interferometric data reduction pipeline, we have synthetized ~480.000 dynamic spectra in full polarisation in the direction of about 85.000 nearby stellar objects (including exoplanetary systems). I propose to present the main results from a preliminary statistical differencial analysis, that lead for the first time to the detection of a global exoplanetary signal arising from about a hundred stellar systems.

keywords:

imaging, calibration, stars, exoplanets

In-person or online?:

in-person

Career level:

Mid-Senior

Poster Sparklers / **43**

Thermal and Non-thermal Processes in the Evolution and Structure Formation in the Center of the Milky Way

Authors: Farideh Mazoochi[1]; Fatemeh Tabatabaei[2]

[1] *IPM (Institute For Research In Fundamental Sciences)*

[2] *Institute for research in fundamental science*

Studying the physics of the interstellar medium in the center of galaxies, specifically the center of the Milky Way, is vital to address the impact of supermassive black holes on their host galaxies. This kind of study has been a prominent topic in field of astronomy from the past until now. In this investigation, by using a novel method, we separate the thermal and non-thermal components of radio continuum (RC) emission at 1.3 GHz frequency at the center of the Milky-Way and then we study the role of magnetic fields in structure formation and evolution, molecular clouds and star formation in the central molecular zone. We conclude that at the center of the Galaxy, the magnetic field has a substantial role in the structure formation and star formation activity.

keywords:

Galactic Center, ISM, Thermal and Non-thermal,Magnetic Field, structure formation

In-person or online?:

unsure

Career level:

Student

Clusters/LSS / **28**

Unveiling the spectral properties of radio halos in the galaxy clusters of the LOFAR survey

Author: Koushika Sri Lakshmi Srikanth[1]

Co-authors: Rossella Cassano [2]; Andrea Botteon [3]; Annalisa Bonafede [4]; Gianfranco Brunetti [5]

[1] *University of Bologna*

[2] *INAF-Istituto di Radioastronomia*

[3] *INAF-IRA*

[4] *Hamburg University*

[5] *INAF - IRA*

Radio halos are formed in the central regions of galaxy clusters as a result of turbulence caused by the merging of clusters. These halos occur when relativistic electrons in the Intracluster medium emit synchrotron radiation. The connection between the radio halos and the dynamics of galaxy cluster has been established but the spectral properties of radio halos have not been tested extensively. This is due to the absence of low-frequency sensitive radio observations. In this talk, I will present preliminary results on a project aimed to address for the first time in a complete sample the statistical spectral properties of radio halos by combining LOFAR and uGMRT data. This project is based on the analysis of a subsample of XX radio halos covered by LoTSS-DR2 (150 MHz), and that were recently followed-up at the uGMRT in band 4 (650 MHz). Finally, we test the existing model of radio halos having a steep synchrotron spectrum. The prospect of the project will be discussed, particularly empathizing the role that these observations will have to test the formation scenario of radio halos.

keywords:

Radio halos, spectral properties, clusters, LOFAR, uGMRT data

In-person or online?:

in-person

Career level:

Student

Poster Sparklers / **66**

Unveiling Magnetic Fields From Star Forming Regions to Diffuse ISM in M31

Authors: Amir Yarahmadi[1]; Fatemeh Tabatabaei[2]; Aritra Basu[None]; Rainer Beck[None]

[1] *IPM(Institute for research in fundamental science)*

[2] *IPM*

Magnetic fields play an important role in the energy balance and structure formation in the interstellar medium (ISM) of galaxies. However, the origin of the magnetic fields on different spatial scales and the link between them are still pressing questions. The Andromeda Galaxy (M31) is an ideal laboratory to investigate the magnetic field from kpc scales down to scales of star-forming regions. To measure the field structure, we need high-resolution and highsensitivity data of polarized intensity as well as Faraday rotation (RM) measures. Thanks to the VLA, RM synthesis can be performed on scales of ~60-100pc and also with high resolution in the Faraday spectrum. We propose L, S, and C band observations of two segments in the 10-kpc ring of M31 to 1) discriminate between the tangled and coherent fields as a function of scale, 2) study the 3-D structure of the coherent field, 3) understand the link between the field in star-forming regions and in the diffuse ISM, and 4) assess amplification theories of the magnetic field.

keywords:

ISM-Magentic field-star-formation

In-person or online?:

in-person

Career level:

Student

Galactic / **129**

Unveiling a hidden population of radio shells with MeerKAT

Author: Cristobal Bordiu[1]

[1] *Osservatorio Astrofisico di Catania (INAF)*

In the past decades, infrared surveys carried out with instruments like Spitzer have revolutionized our understanding of evolved stars, revealing a plethora of ring- and disk-like sources spread across the Galactic Plane. Many of these structures were later confirmed as relics of mass-loss events from massive stars, contributing to a more profound characterization of their interplay with the ISM.

Now, the precursors of the Square Kilometre Array have the potential to play a similar role in the radio window. Thanks to their superb sensitivity and resolution, they enable the detailed study of the circumstellar material around known evolved stars, and also permit an unbiased search for new, unknown evolved objects.

In this talk, we will present the results of a blind search for low angular diameter shells with MeerKAT, combining data from the Galactic Centre mosaic and the SARAO MeerKAT Galactic Plane survey (SMGPS). First, we will describe the search strategy, to later dive into the main outcomes of the project: the detection of over a hundred radio shells of about 1 arcmin in size, not related to any catalogued Galactic sources. Based on available multiwavelength information, our preliminary classification indicates that the sample includes a diversity of objects, including compact supernova remnants, numerous planetary nebulae, and several evolved massive star candidates (possibly Luminous Blue Variables or Wolf-Rayet stars). We will discuss the implications of these findings for the completeness of the census of Galactic radio emitting stars, and the prospects for future, deeper surveys in the SKA era.

keywords:

Milky Way, MeerKAT, survey overview, evolved stars, shells

In-person or online?:

unsure

Career level:

ECR

Clusters/LSS / **79**

Unveiling fossil plasma sources with Decameter observations

Author: Christian Groeneveld[None]

The largely unexplored decameter radio band (10-30 MHz) provides a unique window for studying a range of astronomical topics, and in particular, for studying the non-thermal plasma permeating galaxy clusters. Recent work by Groeneveld et al. (2024, subm.) has effectively opened up this wavelength range for astronomical observations by providing a calibration strategy to correct for the severe ionospheric perturbations. In this presentation, we present images at decameter wavelengths with unprecedented sharpness. This represents more than an order of magnitude improvement over previous decameter studies, both in terms of resolution (45 arcseconds) and sensitivity (12 mJy RMS noise). We have identified four fossil plasma sources in the region surveyed. These rare sources are believed to contain old, possibly re-energised, radio plasma originating from previous outbursts of active galactic nuclei. Notably, two of these sources display the steepest radio spectral index among all the sources detected (α=-1.8 and -1.4). This indicates that fossil plasma sources constitute the

primary population of steep-spectrum sources at these frequencies, emphasising the large discovery potential of ground-based decameter observations.

keywords:

Galaxy clusters, calibration, survey overview, LOFAR, decameter, fossil plasma

In-person or online?:

in-person

Career level:

Student

Surveys / 53

Update on the SKA-Low Aperture Array Verification System 3 (AAVS3)

Author: Jess Broderick[1]

[1] *SKAO*

The Aperture Array Verification System 3 (AAVS3) is a single-station SKA-Low prototype located at Inyarrimanha Ilgari Bundara, the CSIRO Murchison Radio-astronomy Observatory. AAVS3 is a crucial milestone in the SKA-Low project: it is the first instrument owned, operated and maintained by SKAO staff in Australia. Moreover, through the implementation of next-generation prototype digital systems, AAVS3 represents a significant evolution from previous SKA-Low technology demonstrators. I will discuss ongoing commissioning and verification activities with AAVS3. Of particular importance is a comparison with its predecessor, AAVS2, so as to inform a decision on the optimal layout of the antennas in SKA-Low stations. Early engagement with AAVS3 will also be highly beneficial for the development of SKA-Low science operations procedures. I will conclude with a future outlook towards the first of the planned SKA-Low array assemblies (AA0.5), which will comprise six stations and will be deployed by November later this year.

keywords:

SKA-Low commissioning; preparing for SKA science

In-person or online?:

online

Career level:

Mid-Senior

Surveys / 27

Update on the The LOFAR Two-metre Sky Survey

Author: Timothy Shimwell[1]

[1] *Leiden University*

The LOFAR Two-metre Sky Survey is an ongoing deep low frequency survey of the entire northern sky. In 2022 we released LoTSS-DR2 which consisted of images and data products covering about 1/4 of the northern sky. Since then we have gathered a vast amount more data and by mid 2024 LoTSS observations will be over 85% complete with 15,000hrs and 20PB of data recorded. In this talk I shall provide an update on LoTSS including survey progress, challenges, plans for the next data release and ambitions to build upon LoTSS once the upgrade to LOFAR is complete in 2025.

keywords:

survey overview

In-person or online?:

unsure

Career level:

Mid-Senior

Poster Sparklers / **11**

Using Self-Organising Maps to Identify and Classify Complex Radio Sources in Next Generation Surveys

Author: Afrida Alam[1]

[1] *University of Hull*

Radio galaxies often have complex morphologies that are difficult to identify using traditional source finders, necessitating visual inspection of radio maps. The large data volumes of the current generation of radio continuum surveys makes such visual inspection impractical. The objective of my PhD is to identify a more efficient method to identify and classify complex radio sources.

I'm using an unsupervised machine learning method, specifically a 10x10 Self-Organising Map (SOM), which is trained on 251259 sources from the Rapid ASKAP Continuum Survey (RACS). Approximately 90% of these sources were well-matched with the corresponding best-matching neurons in the SOM, which demonstrates its reliability in identifying the different types of radio sources in the dataset. The sources were tagged based on their morphology, including compact, extended, double and triple sources, with approximately 132,050 identified as double sources.

The trained SOM can then be used to predict whether new radio galaxy images can be classified as complex sources or not. This project has the potential to improve the classification of complex radio sources, including those with rare or unusual morphologies, in future surveys. I will discuss the results in this talk.

keywords:

machine learning, radio galaxies

In-person or online?:

in-person

Career level:

Student

Galactic / **38**

Wide-band multi-scale images of the Galactic Plane at low radio frequencies

Author: Silvia Mantovanini[None]

Co-authors: Natasha Hurley-Walker [1]; Gemma Anderson [2]

[1] *Curtin University / International Centre for Radio Astronomy Research*

[2] *ICRAR - Curtin University*

The Murchison Widefield Array is a radio interferometer that, over the years, has operated in different configurations observing the sky with a wide frequency band (72–300 MHz). Phase I observed using an abundance of short baselines to resolve large scale structures (2′– 15◦) reaching a noise level of 50 –100 mJy/beam along the Galactic plane. Phase II, doubling the length of the baselines was able to capture the fine details of the smaller scales (45′′– 20′) with ~mJy/beam noise levels due to the lower confusion limit over long integration times.
The joint deconvolution of these two surveys, performed using a GPU-based Image Domain Gridding (IDG) extension of WSCLEAN, enables to obtain an image of the sky with a synergistic combination of resolution and sensitivity to all spatial scales. We imaged the Galactic plane within 340◦ < l < 260◦ and |b| < 10◦ with an RMS noise varying from 10 to 2 mJy/beam across the observing band, and we are currently working on the region of the Galactic centre.
In this talk I will provide you an overview of the methodology applied to create the images, and I will show some results along with a summary of the science topics we can carry out with these data, such as the consequences of free-free absorption at low radio frequencies.

keywords:

survey, galactic plane, imaging

In-person or online?:

online

Career level:

Student

Surveys / 101

Wide-field continuum observations with Apertif at 1.4GHz: new data release and combine view with LOFAR

Authors: Alexander Kutkin[1]; Apertif Team[None]

[1] *ASTRON*

We present new wide-field mosaic images of Boötes and Lockman Hole obtained with the Aperture Tile in Focus (Apertif) system of the Westerbork Synthesis Radio Telescope. The images were produced using direction-dependent calibration pipeline, showing a significant quality improvement compared to the ones of the first Apertif data release. The images represent a linear mosaic of hundreds of the individual compound beam images obtained with Apertif during 2019-2021. The mosaics have an angular resolution of 27×12 arcseconds and a median background noise of 40 μJy/beam. For both images, we extract the source catalogs and cross-matched the coordinates with the Low Frequency Array (LOFAR) catalog, resulting in one of the largest samples of spectral index estimates at 50-1500 MHz frequency range. We find a spectral flattening towards low flux density sources. Using the spectral index limits from Apertif non-detections we derive that up to 9 percent of the sources have ultra-steep spectra with a slope steeper than -1.2. Steepening of the spectral index with increasing redshift is also seen in the data showing a different dependency for the low-frequency spectral index and the high frequency one. This can be explained by a population of sources having concave radio spectra with a turnover frequency around the LOFAR band. Additionally, we discuss cases

of individual extended sources with an interesting resolved spectral structure. With the improved pipeline, we aim to continue processing data from the Apertif wide-area surveys and release the improved 1.4 GHz images of several famous fields.

keywords:

Radio continuum surveys, catalogs, cross-matching, source finding, imaging, radio spectra

In-person or online?:

in-person

Career level:

Mid-Senior