The Fifth National Workshop on the SKA Project

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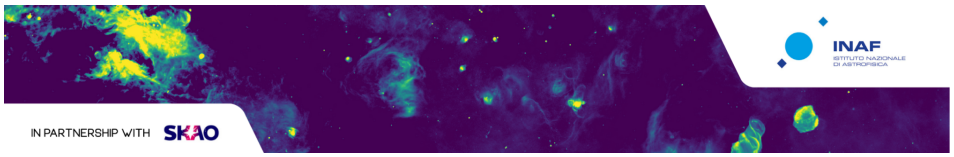

Book of Abstracts

Contents

3

The Euclid view on the connection between mergers and radio activity from galaxies

Author: Manuela Magliocchetti[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: manuela@iaps.inaf.it

We present a joint analysis of the radio and optical morphological properties of LOFAR sources in the Euclid Deep Field North. Radio sources have been separated into AGN and star-forming galaxies and further subdivided according to their radio appearance (e.g. whether point-like or extended/complex). This information has then been complemented with Euclid/VIS images which provide a snapshot of the merging or isolated status of their host galaxies. We find that radio-AGN are mostly associated with merging systems, with a more marked preference observed for complex radio sources (about 50% vs a mere 15% in the case of association with isolated galaxies). The exact opposite is instead found for star-forming galaxies which mostly reside within isolated systems. Thanks to the exquisite statistics provided by Euclid and LOFAR observations which enable us to analyse samples with different luminosities and belonging to different redshift ranges, we will then discuss what the main drivers for the observed trends are, i.e. whether due to cosmological evolution or radio activity.

Topics:

Galaxy Evolution & AGN

4

Exploring the physics of ram pressure stripping in clusters and groups with SKA

Author: Alessandro Ignesti[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: a.ignesti@ira.inaf.it

Satellite galaxies in clusters are significantly more likely to be red and passive than similar mass galaxies in the field. This fact is known as the environmental quenching of galaxy star formation, which is believed to be driven by the ram pressure stripping (RPS). The large velocity differences between the infalling galaxies and the intracluster medium (ICM) result in a strong ram pressure on their interstellar medium (ISM), which can strip it from their stellar disk. The stripped ISM clouds can be studied at various wavelengths, including the radio band, thanks to the synchrotron emission produced by the magnetic fields and relativistic electrons embedded in them. The advent of LOFAR has been revolutionary for the study of RPS in clusters and groups. At low frequencies, the stripped tails can extend for up to 100 kpc in the galaxies' wakes, making them easily detectable in the radio sky. With the exceptional resolution and sensitivity of LOFAR surveys, over a hundred new RPS galaxies have been discovered in the northern sky, proving that RPS is not an isolated occurrence but rather a common phase experienced by every cluster galaxy. Additionally, LOFAR has detected numerous RPS radio tails in groups, demonstrating that this process is also prevalent in low-mass systems, contrary to previous expectations. Furthermore, combined LOFAR, MUSE, MeerKAT, and Chandra studies have provided new insights into the evolution of stripped ISM clouds in the ICM, shedding light on the astrophysical processes of magnetized plasma mixing.
In my talk, I will provide an overview of the current understanding of ram pressure stripping at radio wavelengths and outline the key open questions driving the field. Looking forward, the Square Kilometre Array (SKA) promises to be a transformative instrument. SKA-Low will extend these studies to the southern hemisphere, enabling synergies with major observatories like the upcoming

Extremely Large Telescope (ELT). The combined power of SKA Low and Mid will allow us to map radio emission with a spectral index down to $\alpha=-2$ at a 5-arcsecond resolution. SKA-Mid will also explore the magnetic field geometry induced by the ram pressure, via the detection of polarized emission, and the evolution of the neutral ISM phase, traced by the 21-cm emission.

Topics:

Galaxy Clusters & LSS (relativistic particles and magnetic fields)

5

Prospects of a statistical detection of the 21-cm forest and its potential to constrain the thermal state of the neutral IGM during reionization

Author: Tomas Soltinsky[1]

Co-authors: Girish Kulkarni [2]; James Bolton [3]; Shriharsh Tendulkar [2]

[1] *Istituto Nazionale di Astrofisica (INAF)*

[2] *Tata Institute of Fundamental Research*

[3] *University of Nottingham*

Corresponding Author: tomas.soltinsky@inaf.it

The cosmological 21-cm forest, a series of absorption lines in the spectra of high-z radio-loud sources arising from the hyperfine structure of neutral hydrogen residing in the intergalactic medium (IGM), has a potential to be a unique probe of the neutral IGM during the Epoch of Reionization. While there are no detections of this signal up to date, I will argue that the prospects of detecting the 21-cm forest signal are improving because of (1) recent evidence that reionization ended as late as $z<5.5$, (2) increase in the number of known high-z radio-loud quasars and (3) the improving sensitivity of radio telescopes such as the uGMRT and SKA. In this context, I will present our models of the 21-cm forest signal based on cosmological simulations, in which we simultaneously vary the X-ray background radiation efficiency and ionization state of the IGM. I will discuss the detectability of this signal by the uGMRT and SKA1-low, both direct detection of individual absorption lines and statistical detection. I will finish this talk by showing that the spectroscopical observations of the 21-cm forest signal provide a unique opportunity to constrain the cosmic heating and reionization history at $z\geq6$ even in the case of a null-detection.

Topics:

Epoch of Reionization and Cosmic Dawn

6

Separating baryon and CDM densities in 21-cm simulations

Author: Jordan Flitter[1]

[1] *Scuola Normale Superiore*

Corresponding Author: jordan.flitter@sns.it

The cosmological 21-cm signal is sourced from hyperfine transitions in neutral hydrogen atoms. Yet, although the abundance of hydrogen atoms follows the baryon density field, semi-numerical codes

that simulate the 21-cm signal simplify their treatment as if all the matter in the Universe was in the form of collisionless cold dark matter (CDM). In this talk, I will discuss how separating the baryons from CDM affects the 21-cm signal at the linear dark ages epoch and the subsequent non-linear epochs of cosmic dawn and reionization. Even though the exact separation between baryons and CDM is not critical for analyzing the data from current interferometers, it would become increasingly more important in the future when data from next generation interferometers like SKA becomes available.

Topics:

Cosmology

7

Searching for pulsars in the Galactic center with MeerKAT

Author: Federico Abbate[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: federico.abbate@inaf.it

The idea of finding a pulsar in orbit around the supermassive black hole Sgr A*at the center of our Galaxy has fascinated pulsar astronomers for decades. The number and precision of tests of gravity that could be performed would far exceed those that can be performed nowadays. Further discoveries in the Galactic center have the potential of being revolutionary also for uncovering the nature of Dark Matter and for studies of the surrounding ionized matter.*
The MeerKAT telescope, thanks to the favourable geographical location in the Southern hemisphere and the very high instantaneous sensitivity is poised to play a significant role in uncovering the pulsar population at the Galactic center. The current efforts are, however, hampered by the effects of scattering that can severely limit our sensitivity in particular to fast MSPs. To solve this, we need to observe at higher frequencies.
A collaborative effort between INAF and SARAO is currently providing new receivers to each MeerKAT antenna in the band 5B (8.3 – 15.4 GHz). This new frequency band will transform MeerKAT into the best possible instrument in the world for discovering pulsars in close orbit around Sgr A and for discovering MSPs throughout the Galactic center.

Topics:

Pulsars & GW detection (PTAs)

8

Jets and outflows in young stellar objects in the SKAO Era

Author: Giovanni Sabatini[1]

Co-authors: Gemma Busquet [2]; Luca Cacciapuoti [3]; Carlos Carrasco-González [4]; Claudio Codella [5]; Marta De Simone [6]; Josep Miquel Girart [7]; Antonio Martínez-Henares [8]; Adriana Rodriguez-Kamenetzky [9]; Lukasz Tychoniec [10]; Guillem Anglada [11]; Francesca Bacciotti [5]; Rafael Bachiller [12]; Eleonora Bianchi [1]; Tyler Bourke [13]; Stefano Bovino [14]; Paola Caselli [15]; Francesco Cavallaro [5]; Cecilia Ceccarelli [16]; Elena Diaz-Marquez [17]; Stefano Facchini [18]; Antonio Garufi [5]; Lisa Giani [19]; Guidi Greta [16]; Tomoya Hirota [20]; John Ilee [21]; Adriano Ingallinera [5]; Izaskun Jimenez-Serra [22]; Valerio Lattanzi [23]; Chin-Fei Lee [24]; Manuela Lippi [5]; Alessandro Lupi [25]; Mayank Narang [26]; Mayra Osorio [27]; Jaime Pineda [23]; Linda Podio [5]; Manoj Puravankara [28]; Isaac Radley [29]; Basmah Riaz [30]; Luis Felipe Rodríguez [31]; Alvaro Sanchez-Monge [7]; Alberto Sanna [5]; Silvia Spezzano [23]; Leonardo Testi [32]; Claudia Toci [33]; Alessio Traficante [34]; Tyagi Himanshu [28]; Grazia Maria Gloria Umana [5]

[1] *INAF - Osservatorio Astrofisico di Arcetri*

[2] *Departament de Física Quàntica i Astrofísica, Universitat de Barcelona, ES*

[3] *European Southern Observatory*

[4] *Instituto de Radioastronomía y Astrofísica - UNAM, MX*

[5] *Istituto Nazionale di Astrofisica (INAF)*

[6] *European Southern Observatory Garching - INAF Arcetri*

[7] *Institut de Ciències de l'Espai - CSIC, ES*

[8] *Center of Astrobiology - CSIC-INTA, ES*

[9] *Instituto de Astronomía Teórica y Experimental -UNC, AR*

[10] *Leiden Observatory, NL*

[11] *Instituto de Astrofísica de Andalucía - CSIC, ES*

[12] *Observatorio Astronómico Nacional - IGN, ES*

[13] *SKA Observatory, UK*

[14] *Department of Chemistry, Sapienza - Roma, IT*

[15] *Max Planck Institute for Extraterrestrial Physics*

[16] *Univ. Grenoble Alpes, CNRS, IPAG, FR*

[17] *Departament de Física Quàntica i Astrofísica - U. Barcelona*

[18] *Dipartimento di Fisica, Università degli Studi di Milano, IT*

[19] *INAF- Osservatorio Astrofisico di Arcetri*

[20] *National Astronomical Observatory of Japan, JP)*

[21] *School of Physics and Astronomy University of Leeds, UK*

[22] *Center of Astrobiology (CAB), CSIC-INTA, ES*

[23] *Center for Astrochemical Studies - MPE, DE*

[24] *Academia Sinica Institute of Astronomy and Astrophysics, TW*

[25] *Como Lake Center for Astrophysics, DiSAT, University of Insubria*

[26] *JPL/CalTech, USA*

[27] *Instituto de Astrofisica de Andalucia, EP*

[28] *Tata Institute of Fundamental Research, Mumbai, India*

[29] *School of Physics and Astronomy - University of Leeds, UK*

[30] *Universitäts-Sternwarte München - LMU, DE*

[31] *Centro de Radioastronomia y Astrofisica - UNAM, MX*

[32] *Dipartimento di Fisica e Astronomia, Università di Bologna*

[33] *European Southern Observatory (ESO)*

[34] *INAF - Istituto di Astrofisica e Planetologia Spaziali, IT*

Corresponding Author: giovanni.sabatini@inaf.it

Jets and molecular outflows are ubiquitous phenomena associated with the formation of young stellar objects (YSOs). They play a crucial role in removing angular momentum from the accreting system and in regulating star-formation efficiency. Theoretical studies and observations with ALMA and VLA have shown that jets and winds may have a crucial role in promoting dust growth in the envelope-disc system and in shaping the physical and chemical properties of the surrounding environment. Despite these significant progresses, many fundamental questions remain unanswered regarding the acceleration, collimation, and chemical impact of jets and outflows from YSOs.
From its first light in the AA* configuration, SKA-Mid will overcome the limitations of current mm/cm-facilities by enabling high-angular resolution and high-sensitivity cm-observations, crucial for probing jets and outflows near YSOs. Radio recombination lines offer a unique opportunity to study the 3D-kinematics of jets. Non-thermal linearly polarized synchrotron emission will allow measuring magnetic field strength and morphology at unprecedented scales of a few au, enabling us to test MHD models for wind's acceleration. Simultaneously, observations of dust thermal emission in outflow cavities will allow studying how dust grows and is eventually transported from the disk to the envelope and back, providing a possible solution to the long-standing challenge of dust growth in discs. Finally, the SKA-project will allow exploring the dust composition and chemical enrichment in shocks, where sputtering and shattering of grains cause the release of their mantles and

refractory cores in the gas-phase. Complementary to ALMA's detection of simple and complex organic molecules at mm-wavelengths, the SKA-project will probe for the first time heavy species and give insight into the refractory material of dust grains. Molecules such as long carbon chains/rings, several S-, Al-, Mg-, and other metal-bearing species are expected to have their peak emission at frequencies covered by SKA-Mid but are missed by sub-mm facilities.
In the context of the Cradle-of-Life, this talk will discuss the revolution that SKA-Mid will enable in the study of jets and outflows from YSOs leading to a deeper understanding of the star-formation process and the evolution of the ISM in our Galaxy.

Topics:

Cradle of Life & Our Galaxy

9

Galaxy dynamics with statistical HI samples in the SKA era

Author: Konstantin Haubner[1]

Co-authors: Enrico Di Teodoro [2]; Federico Lelli [1]; Francis Duey [3]; James Schombert [4]; Kelley Hess [5]; Stacy McGaugh [3]; The Apertif Team

[1] *Istituto Nazionale di Astrofisica (INAF)*

[2] *Università degli Studi di Firenze*

[3] *Case Western Reserve University*

[4] *University of Oregon*

[5] *Onsala Space Observatory*

Corresponding Author: konstantin.haubner@unifi.de

The nature of dark matter (DM) is one of the biggest open questions in modern astrophysics. A crucial role in establishing this problem was played by radio observations of the 21-cm line of atomic hydrogen (HI), which revealed that the HI rotation curves of galaxies remain flat out to large radii, well beyond their stellar components. In synergy with near-infrared images that probe the stellar mass distributions of galaxies, HI rotation curves continue to be a major tool to test different DM models, galaxy formation models, and modified gravity theories. A key step in this context was the SPARC (Surface Photometry and Accurate Rotation Curves) project, which provided HI rotation curves and mass models for 175 disk galaxies at z = 0. However, SPARC has several limitations, such as data heterogeneity and limited statistics, which prevents more powerful tests of ΛCDM and alternative theories. To address these issues, I am working on the successor database BIG-SPARC, which combines spatially resolved HI data for almost 4,000 galaxies with WISE near-infrared photometry. The HI data for BIG-SPARC come both from public telescope archives (ASKAP, ATCA, GMRT, VLA, WSRT), as well as from the Apertif survey, which is the largest contributor. This new database increases the sample size of SPARC by a factor of more than 20, therefore allowing us to test different DM models and modified gravity theories with unprecedented statistical power. Nevertheless, BIG-SPARC represents just a small, intermediate step on the way to a further order-of-magnitude increase in sample size from potential future HI surveys with SKA-MID AA*.

Topics:

Galaxy Evolution & AGN

10

Collapse of the galaxy HI mass function in the Fornax cluster

Author: Paolo Serra[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: paolo.serra@inaf.it

The low-mass end of the HI mass function (HIMF) is thought to be a sensitive probe of environment-driven galaxy evolution. The general expectation is that, at low MHI, the HIMF becomes flatter as the environment density increases because of the removal of HI from small galaxies. The main challenge to measure this effect reliably is to have enough HI detections and/or go sufficiently deep in MHI. The MeerKAT Fornax Survey detects HI in the Fornax cluster down to below 1e+6 Msun, and thus provides a good sample for this type of work. We find that the Fornax galaxy HIMF follows a Schechter function comparable to that of the field down to MHI ~ 1e+7 Msun, and collapses abruptly below this value. The collapse occurs at SNR ~ 20, which makes us confident that it is not caused by the incompleteness of the HI catalogue. I will discuss our result in the context of previous studies which, using more complex techniques on shallower data, also suggest that the HIMF may collapse at some low MHI value in clusters.

Topics:

Galaxy Evolution & AGN

11

What is the nature of Neutral Hydrogen tails in the MeerKAT Fornax Survey?

Author: Sambatriniaina Hagiriche Aycha Rajohnson[1]

Co-author: Paolo Serra [1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: sambatriniaina.rajohnson@inaf.it

Galaxies undergo diverse evolutionary processes depending on their environment, often leaving clear imprints in their neutral hydrogen (HI) content and morphology. In cluster environments, HI tails are common and serve as indicators of gas removal through tidal and/or hydrodynamical interactions. Yet, the dominant mechanisms responsible for these features remain debated. The Fornax cluster, a nearby low-mass system, offers an ideal setting to explore these questions under conditions typical for most galaxies in the Universe.
Observed through they eye of the SKA precursor MeerKAT —with an exceptional sensitivity down to 6×10^5 $M_\odot$ and $\sim$1 kpc resolution at 20 Mpc —Fornax has been imaged in unprecedented detail, revealing widespread HI removal and gas tails in its galaxies.
I will present a classification of the different stages of gas stripping in 35 HI-detected galaxies within the cluster's virial radius. Our preliminary results reveal a rich diversity of gas-removal stages, including galaxies undergoing tidal stripping, early and ongoing Intra-Cluster Medium (ICM) interactions, starvation, and potential re-accretion. In several cases, a combination of tidal and hydrodynamical processes appears responsible for the observed HI structures.
This work demonstrates the power of spatially resolved HI studies in constraining the physical mechanisms driving galaxy transformation. With the upcoming SKA, such analyses will scale to thousands of galaxies across environments and redshifts, enabling a statistical understanding of gas stripping and its role in galaxy evolution.

Topics:

Galaxy Evolution & AGN

12

A case for a SKA-low wide area survey: the Cosmic Ray life cycle in galaxy clusters

Author: Francesco De Gasperin[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: fdg@ira.inaf.it

In recent years, LOFAR conducted wide area surveys at low and ultra-low frequencies. These surveys were a fundamental exercise to learn what to do and what NOT to do when performing such large and complex observations. In this talk I will present the challenges and the main results of the LOFAR LBA Sky Survey (LoLSS), that covers the sky at declination >24 deg, and it is the deepest and highest resolution large radio survey at <100 MHz to date. I will then discuss the lessons learned with this project and what we could (and should) do with SKA-low to maximise its scientific outcome. I will discuss topics such as: scheduling, confusion and the importance of the solar cycle. Based on these recommendations, I will outline a possible strategy for a deep full-sky survey done with SKA-low.

Among the main scientific results of LoLSS, I will discuss the use of these datasets to study the cosmic ray life cycles in galaxy clusters. I will cover the evidence of the re-acceleration of CR of AGN origin though turbulence and the conclusive evidence of the origin of radio halos through turbulence acceleration. Building on techniques and strategies developed for LoLSS, SKA-low will be able to survey the sky at unprecedented sensitivity. This will enable the investigation of the previously invisible large reservoir of low-energy cosmic rays that may be accelerated by still unexplored microphysical mechanisms. Through large surveys and pointed deep observations, SKA-low will unveil the full cosmic ray life-cycle in galaxy clusters.

Topics:

Galaxy Clusters & LSS (relativistic particles and magnetic fields)

13

Illuminating the dark Universe through strong gravitational lensing in the SKA era

Author: Cristiana Spingola[1]

[1] *INAF - Istituto di Radioastronomia*

Corresponding Author: spingola@ira.inaf.it

Dark matter and dark energy represent 95% of the Universe and they are still unknown. Gravitational lensing is one of the most powerful tools for constraining the “dark Universe”, as it can directly infer dark energy (via gravitational time delays) and dark matter (via low-mass lenses). In this talk we will overview these fundamental investigations and show our latest results from the combination of strong lensing and VLBI, which can reveal low-mass haloes ($\sim 10^6$ $M_\odot$) and measure time delays at high precision.

These studies are currently limited by the paucity of lensing systems known. Finding novel and effective ways to identify strong lenses represents a new challenge that has to be addressed now, when the so-called “era of precision cosmology” is about to start with the next generation of telescopes. We will present novel methods to search for strong lenses in the radio and in the time domain that, teamed-up with the SKA-VLBI, can shed light on these open questions at unprecedented precision.

Topics:

Cosmology

14

Large-scale jets from black hole X-ray binaries in the SKA era

Author: Francesco Carotenuto[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: francesco.carotenuto@inaf.it

Black hole X-ray binaries (BH XRBs) can launch powerful outflows in the form of radio-emitting discrete jet ejecta, which are observed to be produced during outburst phases, at the transition between different accretion states.

Once spatially resolved, these components are observed to propagate up to parsec scales far from the BH, often displaying apparent superluminal motion. However, little is known about the powering mechanism, the formation and composition of these jets, and studying them is important for understanding both their physics and the feedback that BH XRBs have on the surrounding environment. While discrete ejecta have been historically difficult to detect and to follow in their motion away from the compact object, MeerKAT is now "changing the game"in this field with its exceptional sensitivity and imaging capabilities at GHz frequencies.

In this talk, I will show how MeerKAT observations of active BH XRBs taken as part of the ThunderKAT LSP and the subsequent X-KAT program have been fundamental for obtaining an extensive, unprecedented coverage of the jet propagation at parsec scales, allowing us to easily double the sample of discrete ejecta known today. Thanks also to new monitoring strategies, these new data-sets are becoming more and more suitable for a complete physical modelling that includes constraints on the jet energy, speed and mass.

In the talk, I will highlight what will be possible to to achieve with the advent of SKA in its AA* stage. Thanks to its enhanced sensitivity and resolution, we will be able to probe in detail the final phases of the jet propagation, while, at the same time, resolving the ejecta much earlier after their launch. Taking advantage of the broad radio spectral coverage (band 1 to 5b), we will probe the jet spectral properties and their evolution, gaining insight into the details of particle acceleration throughout the jet motion. Finally I will discuss how this new wealth of information will be essential for new joint radiative-kinematical modeling efforts that are currently starting and which allow us to effectively use these jets as laboratories where the shock evolution can be studied in real time.

Topics:

Transients & GW follow-up

15

One step closer to planet formation

Author: Antonio Garufi[1]

[1] *Istituto di Radioastronomia*

Corresponding Author: antonio.garufi@inaf.it

In recent years, ALMA has revealed an astonishing variety of disk structures, though the precise relationship between these morphologies and planet formation remains elusive. A major challenge with ALMA is its limited sensitivity to larger dust grains (those approaching centimeter scales) which are crucial for understanding early stages of planet formation. Moreover, the common occurrence of optically thick emission at millimeter wavelengths complicates efforts to accurately determine dust properties and disk masses.

This work assesses how the SKA could overcome these observational limitations. By synthesizing data from both ALMA and VLA surveys we generate statistical forecasts for the SKA's ability to conduct population studies of protoplanetary disks. Specifically, we evaluate detectability, resolvability, and the level of characterization achievable with SKA AA*. From an analysis of 400 known disks within 200 parsecs, our findings suggest that more than a half can be detected within a three-hour integration time, with two or three dozens of these offering sufficient spatial extent for detailed imaging in a reasonable telescope time.

We discuss how an initial survey using the SKA could significantly advance our knowledge of planet formation, particularly by constraining the total dust content, characterizing grain growth, and shedding light on other critical physical processes in disks. We also outline the enhanced capabilities expected from the forthcoming AA4 configuration and their implications for future studies.

Topics:

Cradle of Life & Our Galaxy

16

Understanding the AGN accretion and ejection physics with SKA-VLBI observations

Author: Francesca Panessa[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: francesca.panessa@inaf.it

The accretion-ejection mechanism acting in Active Galactic Nuclei (AGN) is one of the main astrophysical open issues, being connected to the role of AGN feedback in galaxy formation evolution studies. Radio Quiet AGN constitutes the large majority of radio sources in the sky. The absence of luminous jets allows us to investigate their radio emission originating from a wide range of possible mechanisms, from the host galaxy kpc scale down to the innermost region near the SMBHs: star formation, AGN driven wind, free-free emission from photo-ionized gas, low power jet, and the innermost accretion disc coronal activity. All these mechanisms will be probed over a wide range of frequencies with unprecedented sensitivity, wide-field survey capabilities and in particular with high-resolution imaging of VLBI. Monitoring variability and spectral properties will help understand dynamics and environmental interactions. Nuclear regions will be mapped from sub-pc to kpc scales. With these tools, we will address the diversity of AGN populations and their radio activity mechanisms from the local Universe to the cosmic dawn, across different accretion regimes and jet powers. Here, we discuss strategic observational approaches, theoretical frameworks, and the integration of multi-wavelength data to disentangle the contributions of various emission components. Our aim is to bridge gaps between observations and theory, with the aim of advancing our knowledge of accretion and ejection processes and their role in shaping the cosmos.

Topics:

Galaxy Evolution & AGN

17

ESO SKA Synergy: Cross-correlating 21-cm with Lyman alpha emitters during the Epoch of Reionization

Author: Samuel Gagnon-Hartman[1]

[1] *Scuola Normale Superiore di Pisa*

Corresponding Author: samuel.gagnonhartman@sns.it

The Epoch of Reionization (EoR) remains one of the last frontiers of observational cosmology. The Square Kilometer Array (SKA) is poised to make a preliminary detection of the 21-cm EoR signal within the next decade, and the race will ignite for a confirmation of this detection. One of the most promising avenues is through cross-correlation with galaxies in the same field. I present a framework for self-consistently simulating 21-cm and Lyman alpha emitter fields and then computing their cross-power spectrum, including forecasts of the achievable signal-to-noise ratio of a cross-correlation measurement made with various survey configurations. I highlight the potential of ESO MOSAIC spectroscopy to help us understand an early detection of the 21-cm EoR signal from the SKA in its AA* configuration.

Topics:

Epoch of Reionization and Cosmic Dawn

18

Strongly Lensed Dual AGN Systems in the Era of SKA-VLBI

Authors: Cecilia Stella[1]; Cristiana Spingola[2]; Daniele Dallacasa[1]

[1] *University of Bologna / INAF-IRA*

[2] *INAF - Istituto di Radioastronomia*

Corresponding Author: lau96@ira.inaf.it

As an intermediate stage of the merging process, we expect to observe pairs of Active Galactic Nuclei (AGN), in particular at high$-z$ when the mergers were most frequent. Nevertheless, to date there is only one confirmed AGN pair at high redshift ($z = 2.1$) clearly hosted by a galaxy merger, with a projected separation of 3.8 kpc. The critical population to really test galaxy (and SMBH) evolution models is that of low-separation (hundreds of pc) AGN pairs, as they trace the final stages of mergers, and they are the progenitors of the loudest sources of gravitational waves (GWs) in the nHz regime. These systems at high$-z$ can be spatially resolved only with very long baseline interferometry (VLBI) observations.

By combining the magnifying power of strong gravitational lensing, VLBI and archival X-ray observations, we have likely detected the first example of a close pair of jetted AGN at $z > 3$ (separated by 175 pc in projection). This dual AGN candidate is strongly gravitationally lensed, which gives us the opportunity to put observational constraints on the statistics of dual AGN systems at high redshift.
Also, the timescales on which multiple SMBHs can coalesce are not known, but it is expected to be short given the low detection rate of such systems. Therefore, observations of small separation dual AGN are needed in order to directly probe the (unknown) timescales of the final stages of the merging process.

In this poster, we will show the results of a sensitive multi-band and multi-scale follow-up of the lensed dual AGN candidate MG B2016+112. This dataset and the intrinsic μJy-level flux density of the source anticipate what SKA surveys and SKA-VLBI follow-up observations will reveal at the largest distances and at the highest angular resolution.

Topics:

Galaxy Evolution & AGN

19

Magnetic fields in galaxy clusters in the SKA (and its precursors) era

Author: Annalisa Bonafede[1]

[1] *Bologna University & INAF*

Corresponding Author: annalisa.bonafede@unibo.it

Magnetic fields play an important role in the Intra Cluster Medium (ICM) of galaxy clusters. Indeed, they mediate particle acceleration mechanisms, thermal conduction, and contribute to the ICM pressure and energy budget. Yet, magnetic fields are so far constrained only for a small sample of clusters, observed in different ways, which might introduce biases in the analysis.
In this talk, I will present the first results of the MeerKAT XLP "CHEX-MATE-KAT: tracing magnetic field amplification in galaxy clusters during the process of structure formation", which aims at constraining the magnetic field in a well defined sample of galaxy clusters. The sample of clusters has a uniform coverage in the X-rays up to R_500 (i.e. half of the virial radius), which is optimal for a systematic and unbiased analysis of the Faraday rotation Measure.
We have observed and analysed through the Rotation Measure Synthesis technique the first set of observations: 6 low mass galaxy clusters (M500 2-4 1e14 Msun), and 3 high-mass clusters (M> 7e14 Msun M500) at low redshift (z < 0.2). I will show how these observations can be used to set constraints on the magnetic field evolution as a function of the cluster mass. I will also show how, once completed, this XLP will permit to study the evolution of magnetic fields in clusters through mass and redshift.

Topics:

Galaxy Clusters & LSS (relativistic particles and magnetic fields)

20

The Large-Scale Structure on the Universe through the SKA lenses

Author: Virginia Cuciti[1]

[1] *University of Bologna - Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: v.cuciti@ira.inaf.it

The evolution of the Universe proceeds along the filaments of the cosmic web, where enormous amount of energy is dissipated through complex plasma processes that can be traced by radio emitting electrons. While the central regions of galaxy clusters, located at the knots of the cosmic web, have been studied in fair detail, their outskirts are still poorly explored, and cosmic filaments have remained elusive so far. The initial step in this direction has arrived thanks to the Low Frequency Array (LOFAR). LOFAR has recently discovered that some clusters host Megahalos, diffuse sources filling the volume of clusters up to their periphery (Cuciti et al. 2022, Nature). In a few cases, LOFAR detected large radio structures connecting pre-merging clusters, called "radio bridges"(Botteon et al., 2020; Govoni et al. 2019, Science). Galaxy clusters and filaments are expected to be surrounded by strong accretion shocks that should be able to accelerate cosmic rays. The signatures of accretion

shocks however have been only detected by stacking radio surveys in polarisation (Vernstrom et al. 2023, Science Adv.). These discoveries represent the first steps in the exploration of the large scale structure of the Universe in the radio band. SKA, with its unprecedented sensitivity, is going to enable the systematic observation of these sources and possibly open the possibility to detect cosmic filaments. Given that the synchrotron diffuse sources beyond galaxy clusters typically have steep spectra (alpha <-1), SKA-LOW and band 1 of SKA-MID will be the most suitable for this kind of studies. We estimated that with 1 hour integration time SKA-LOW in stage AA* will be about 6 times more sensitive than LOFAR, at a comparable resolution. The combination of SKA-LOW and SKA-MID will ensure a proper characterisation of the spectral properties of these sources, which is paramount to understand the acceleration mechanisms at play outside galaxy clusters.

Topics:

Galaxy Clusters & LSS (relativistic particles and magnetic fields)

21

Magnetic fields in proto-clusters towards the SKAO era

Author: Annalisa Pagliotta[1]

[1] *University of Bologna, INAF - IRA*

Corresponding Author: annalisa.pagliotta@inaf.it

Magnetic fields are everywhere in the Universe, but little is know about their origin and amplification, particularly on the largest scales. Proto-clusters, the distant progenitors of local galaxy clusters, offer a unique environment to study magnetic fields during the first phases of structure formation and especially to understand the magnetic field amplification during this process. However, little is known at present about magnetic fields in proto-clusters.

Using the Jansky Very Large Array, we have started the first systematic study of magnetic fields in proto-clusters, selected from the CARLA (Clusters Around Radio-Lod AGN) sample. Our sample comprises 9 spectroscopically confirmed objects within $1.37 < z < 2.80$, with masses $13.6 < \log_{10}\mathrm{M_{halo}}\,[\mathrm{M_\odot}] < 14.6$, and that host a powerful polarised radio-loud AGN.

To study magnetic fields in proto-clusters, we analyse the Faraday rotation effect of the polarised emission from the central AGN jets and lobes. As this radiation propagates through the hot, sparse, and magnetised proto-intra-cluster medium (proto-ICM), its polarisation angle is rotated by the Rotation Measure (RM), which traces the line-of-sight magnetic field and electron density. Measuring the RM and its dispersion allows us to probe the magnetic field structure and disentangle contributions from the AGN and the surrounding medium.

In one of these objects, CARLA J1510+5958, we find uniform RM and well-ordered magnetic field vectors in one of the radio lobes, indicating that the AGN may be compressing a magnetised medium in its vicinity. In contrast, the opposite lobe shows complete depolarisation, which is consistent with it being embedded in a hot, low-density, and turbulent magnetised plasma. Together, these results point to the existence of a magnetised proto-ICM. By comparing our observations with 3D semi-analytical simulations, we estimate a lower limit on the physical magnetic field strength of approximately 0.05 μG.

In the talk, I will present these preliminary findings and outline how the SKA Observatory, with its high sensitivity, resolution, and wide bandwidth, will open a new window to map magnetic fields in proto-clusters and help our understanding of the cosmic magnetism.

Topics:

Galaxy Clusters & LSS (relativistic particles and magnetic fields)

22

Unveiling radio polarimetry in X-ray binaries with MeerKAT: the case study of 4U 1630-47

Author: Isabella Mariani[1]

Co-authors: Andrew Hughes [2]; Melania Del Santo [1]; Sara Elisa Motta [1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

[2] *University of Oxford*

Corresponding Author: isabella.mariani@inaf.it

X-ray binaries (XRBs) hosting a stellar mass black hole (BH) or a neutron star exhibit a powerful emission triggered by accretion of matter onto the compact object from the companion star; this process may lead to the formation of fast, collimated outflows, called jets. Most BH-XRBs are transients, producing steady, mildly relativistic compact jets during quiescence and the low-luminosity 'hard' state, while they launch discrete, apparently superluminal ejecta with a steep synchrotron spectrum during transitions to brighter, softer states. Polarimetric observations of these jets can provide information about their magnetic field structure and geometry. However, despite the theoretical expectation of up to ~70% linear polarisation from synchrotron emission at radio frequencies, such emission has been detected in only a handful of XRBs, and typically at levels below ~20%. This discrepancy is likely due to a combination of instrumental and physical depolarisation effects, including beam depolarisation and Faraday rotation.
4U 1630–47 is a recurrent BH-XRB transient that undergoes outbursts every ~600 days. During its most recent outburst in April 2025, it reached an unusually bright radio state, with a peak flux of 26 mJy at 1.3 GHz, the highest measured to date from this source. We monitored 4U 1630–47 in both X-rays and radio using the Swift satellite and the MeerKAT interferometer. I will present the results of this multi-wavelength campaign, with particular emphasis on the radio polarimetry results. We observed strong depolarisation at lower frequencies, indicative of an extremely high Rotation Measure (RM) –potentially the largest ever detected in an X-ray binary. RM-synthesis analysis suggests that the depolarisation is most likely due to internal Faraday rotation. Modelling the RM, we constrained the de-rotated polarisation angle and measured the fractional polarisation of the source. This study demonstrates that MeerKAT is an excellent instrument for investigating the polarisation properties of X-ray binaries in the radio band, paving the way for even more detailed studies with SKA.

Topics:

Transients & GW follow-up

23

Gamma-ray bursts in the radio sky: the role of the SKA+VLBI

Authors: Stefano Giarratana[1]; Giancarlo Ghirlanda[1]; Marcello Giroletti[1]; Om Sharan Salafia[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: stefano.giarratana@inaf.it

Long gamma-ray bursts (GRBs) are among the most powerful explosions in the Universe, marking the catastrophic death of a massive star and the birth of a spinning, stellar mass black hole. This central engine launches two jets of ionised matter which eventually interact with the circumburst medium through external shocks, producing the so called afterglow phase. Radio observations, particularly with the very long baseline interferometry (VLBI) technique, are fundamental to measure the apparent superluminal expansion (on-axis GRB) and proper motion (off-axis GRB) of the GRB outflow, to constrain its structure and to characterise the circum-burst medium. In this talk, I

will review the contributions of VLBI to GRB studies, focusing on GRB030329A, GRB170817A and GRB221009A. While VLBI has already proven fundamental, constraining the blast wave geometry and the viewing angle remains extremely challenging with current instruments, even in the most favourable cases. The advent of the SKA, with its unprecedented sensitivity, has the potential to be a game changer. I will discuss the expected impact of combining the SKA with VLBI in future GRB studies, based on simulated observations of various GRB scenarios.

Topics:

Transients & GW follow-up

24

Accretion and jets in X-ray binaries: the revolution brought by MeerKAT

Author: Sara Elisa Motta[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: sara.motta@inaf.it

The inflow of matter onto astronomical objects is linked to the generation of outflows across the Universe, ranging from proto-planetary disks to merging neutron stars and gamma-ray bursts, to stellar-mass and supermassive black holes.
Low-mass X-ray binaries, hosting either stellar-mass black holes or neutron stars, are the most common type of transient in the Galaxy and exhibit bright jets detected in the radio band.

Compact jets from X-ray binaries, typical of hard accretion states remain unresolved at most angular scales, with only a few cases spatially resolved by milli-arcsecond observations. For years, such high-resolution observations were considered the only way to detect and track the transient jets launched in intermediate accretion states, although they are technically demanding and must be carried out shortly after launch.

The advent of MeerKAT has transformed our view of X-ray binary jets. It has more than doubled the number of black hole jet detections in the hard state, most with simultaneous X-ray coverage, revealing new features of the accretion-jet coupling and associated physical processes.
Even more remarkably, MeerKAT has shown that transient relativistic jets, when observed with sufficient surface brightness sensitivity, can be tracked from launch to terminal deceleration in the interstellar medium over months to years. In six years, it has tripled the sample of such jets, providing the most comprehensive data set available to constrain black hole jet power, which has been instrumental in proposing a new jet paradigm.

I will present some of the key results obtained in the study of X-ray binaries with MeerKAT, highlighting the most significant discoveries and their implications.

Topics:

Transients & GW follow-up

25

The HI mass function and the HI density parameter at z~0.37 from the MIGHTEE and CHILES surveys

Author: Francesco Sinigaglia[1]

Co-authors: Alessandro Bianchetti [2]; Giulia Rodighiero [3]; Mattia Vaccari [4]

[1] *Università degli Studi di Padova*

[2] *Istituto Nazionale di Astrofisica (INAF)*

[3] *University of Padova*

[4] *University of the Western Cape*

Corresponding Author: francesco.sinigaglia@phd.unipd.it

The HI mass function is a crucial tool to understand the evolution of the HI content in galaxies over cosmic times, and hence, to constrain both the baryon cycle in galaxy evolution and the reionization history of the Universe. However, the intrinsic faintness of the 21cm line has made it hitherto prohibitive to measure it directly from HI galaxy surveys beyond the nearby Universe. In this talk, I present recently-derived semi-empirical constraints on the HI mass function and the $\Omega_{\rm HI}$ parameter at $z \sim 0.37$. Specifically, we leverage the combination of literature results on the stellar mass function from optical surveys with recent findings on the $M_{\rm HI} - M_\star$ scaling relation derived via spectral stacking analysis applied to 21-cm line interferometric data from the MIGHTEE and CHILES surveys, conducted with the MeerKAT and VLA radio telescopes, respectively. We find evolution of the HIMF at $z \sim 0.37$ with respect to results at $z \sim 0$ from the ALFALFA survey and at $z \sim 1$ from uGMRT data. Our results for $\Omega_{\rm HI}$ are in broad agreement with other literature results, and follow the overall trend on $\Omega_{\rm HI}$ as a function of redshift, deviating at $\sim 2.9\sigma$ from the ALFALFA result at $z \sim 0$. Our findings therefore hint towards an evolution of the HIMF and of the cosmic HI density over the last 8 billion years, supporting a picture of smooth transition of the HI content of star-forming galaxies from $z \sim 0$ to $z \sim 1$.

Topics:

Galaxy Evolution & AGN

26

Fast large-volume HI intensity mapping simulations for cosmological analysis

Author: Francesco Sinigaglia[1]

[1] *Università degli Studi di Padova*

Corresponding Author: francesco.sinigaglia@phd.unipd.it

Generating a large set of HI intensity mapping simulations encompassing large cosmological volumes implies a prohibitive computational burden if one relies on traditional N-body-based methods. As such, a number of alternatives to overcome this issue have emerged over the years, from simple analytical prescriptions to more complex semi-empirical methods. In this talk, I will present an effort to produce such simulations in a fast but accurate way. These are obtained by combining dark matter fields in V=(10 Gpc/h)^3 volumes with smooth redshift evolution and full-sky lightcone geometry, generated with Augmented Lagrangian Perturbation Theory, with advanced field-level Eulerian bias prescriptions. In addition, these simulations are equipped with observational systematics mimicking SKA data. I will show that, in contrast to other simpler methods based e.g. on lognormal fields, our simulations include a high degree of nonlinearity and model correctly e.g. the BAO peak shift and broadening. Therefore, they represent an ideal tool to estimate covariance matrices and perform cosmological analysis such as BAO and full-shape analysis. Furthermore, I will discuss the prospect to generate the optical galaxy surveys simulations counterpart, to be able to perform cross-correlation studies with Euclid, DESI, and other state-of-the-art surveys.

Topics:

Cosmology

27

The MHI-Mhalo relation in the cosmic web

Author: Francesco Sinigaglia[1]

[1] *Université de Genève*

Corresponding Author: francesco.sinigaglia@phd.unipd.it

THe $M_{\rm HI} - M_{\rm halo}$ relation is a fundamental tool in cosmology, to perform cosmological inference from HI surveys. This relation has been so far constrain observationally in a robust way only in the nearby Universe, and has been studied in theory from state-of-the-art cosmological hydrodynamic simulations. Nonetheless, no dependence on secondary properties (also called 'assembly bias') has been considered so far. In this talk, I present the ongoing effort to characterize the dependence of the $M_{\rm HI} - M_{\rm halo}$ relation on the large-scale structure cosmic web environment across redshifts, lifting the assumption that such a relation is the same everywhere in the Universe irrespectively of the underlying physics. In particular, correctly describing the dependence of this relation on the cosmic web allows us to capture the effect of the formation and growth of cosmic structures and of baryon effects on the HI content of haloes, which in turn regulates the availability of HI fuel to sustain star formation, and hence to also better understand the baryon cycle of galaxies.

Topics:

Cosmology

28

Chemical complexity in the early stages of star formation in the SKA era

Authors: Claudio Codella[1]; Eleonora Bianchi[2]; Linda Podio[1]; WG Cradle of Life[None]

[1] *Istituto Nazionale di Astrofisica (INAF)*

[2] *INAF - Osservatorio Astrofisico di Arcetri*

Corresponding Authors: codella@arcetri.inaf.it, linda.podio@inaf.it

Over 300 molecules have been identified in the interstellar medium (ISM), including complex species considered precursors to prebiotic chemistry. A remarkable level of molecular diversity has been observed from the earliest stages of star formation, providing the initial chemical inventory inherited by planetary systems.

(Sub-)millimeter observations have revealed complex organic molecules of prebiotic relevance, such as formamide (NH_2CHO) and glycolaldehyde (CH_2OHCHO). However, (1) in dense protostellar and protoplanetary systems, dust opacity hampers the detection of molecular emission in the aforementioned spectral window. Additionally, (2) large molecules and heavy atoms, which have rotational transitions at lower frequencies, remain inaccessible in this range. Recent deep surveys in the centimeter range with the Yebes 40m and Green Bank 100m telescopes have unveiled previously overlooked chemistry, detecting long carbon chains, cyanopolyynes up to $HC_{11}N$, benzyne (o-C_6H_4), indene (C_9H_8), and glycolamide ($NH_2C(O)CH_2OH$). These species may play a crucial role in transferring organic material from early star-forming phases to planetary system bodies like asteroids and comets.

SKA-Mid, in its first-light AA* configuration, will provide an unprecedented combination of sensitivity and angular resolution at centimeter wavelengths, enabling deeper and more comprehensive searches for prebiotic molecules in star-forming regions. Deep surveys of high-mass clouds will allow the discovery of new prebiotic species including those containing rare elements (e.g., S and P), while observations of low-mass prestellar cores and protostellar envelopes will help clarify their formation mechanisms and the processes that pass chemical complexity to forming planets. Finally, we will discuss the potential of the final AA4 configuration to probe the innermost regions of protostellar systems, providing new insights into the chemical pathways that shape emerging planetary systems.

Topics:

Cradle of Life & Our Galaxy

29

SKA contribution to multi-band and multi-scale studies of nearby galaxies

Author: Rosita Paladino[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: rosita.paladino@inaf.it

Nearby galaxies offer an invaluable bridge between detailed, cloud-scale observations within the Milky Way and the integrated view of star formation in distant systems.
Thanks to ALMA, molecular gas structures, where star formation happens, can now be studied at sub-parsec scales in local galaxies.
Meanwhile, LOFAR (the Low-Frequency Array) has improved our understanding at the other end of the spectrum, producing low-frequency images that trace non-thermal synchrotron emission from cosmic rays, crucial byproducts of massive star formation.

This talk presents recent progress from the LOFAR Nearby Galaxies Working Group, mainly focusing on the refinement of the low-frequency radio continuum–star formation rate relation, and on insights into how cosmic-ray transport and magnetic fields shape the observed radio emission.

Looking ahead to the Square Kilometre Array, its broader frequency coverage and enhanced sensitivity promise to complement LOFAR by capturing both non-thermal and thermal components at unprecedented resolution.
The synergy will deepen our multi-band, multi-scale understanding of how galaxies form stars,transport cosmic rays, and build magnetic structures over cosmic time.

Topics:

Galaxy Evolution & AGN

30

AGN feedback in the most massive structures: the SKA perspective on how radio jets heat galaxy groups and clusters

Author: Francesco Ubertosi[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: francesco.ubertosi2@unibo.it

Over the past few decades, it has become clear that brightest cluster galaxies (BCG) of galaxy groups and clusters maintain the thermal balance of their surrounding halos through radio jet activity. Yet key questions remain: how frequently their black holes are triggered, how jet orientations evolve over time, and through which physical channels (bubbles, shocks, turbulence) feedback operates. These uncertainties persist partly because the relevant spatial scales span from a few parsecs to tens of kiloparsecs. Probing this range in the radio band has so far required long observations with multiple facilities, restricting detailed studies to only a handful of objects. Even so, these few cases have revealed the complexity of feedback and jet behavior in cluster radio galaxies. I will focus on this complexity by presenting our recent investigations into different topics of AGN feedback in clusters: linking the parsec and the kpc scales with sensitive radio observations; tracing pc-scale jet reorientation using high-resolution VLBI techniques; and identifying the oldest feedback episodes as fossil radio remnants extending hundreds of kpc. These studies - carried out by combining data from a wide range of radio observatories, including the JVLA, LOFAR (with international stations), MeerKAT, e-MERLIN, VLBA, and EVN - highlight the need for high-resolution imaging that also recovers diffuse, large-scale emission. The SKA telescope will enable such studies in larger samples of BCGs, which is required to connect the time evolution of jets in radio galaxies with the thermal structure of their surrounding atmospheres.

Topics:

Galaxy Clusters & LSS (relativistic particles and magnetic fields)

31

Particle Acceleration and Magnetic Fields in Abell 3667: A Multi-Band Polarimetric Study in Preparation for SKA

Author: Alessandro Benati[1]

Co-author: Francesco De Gasperin [1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: a.benati@ira.inaf.it

As a precursor to SKA-Mid, MeerKAT provides an unprecedented opportunity to study the synchrotron emission and magnetic field properties of galaxy clusters through high-sensitivity, wide-band polarimetric observations. Radio relics, elongated and polarized sources found at the outskirts of merging clusters, trace shocks in the intracluster medium (ICM) and provide key insights into particle acceleration mechanisms. In this talk, I will present a new MeerKAT's UHF band (544–1087 MHz) observation of Abell 3667, a cluster showing a spectacular pair of radio relics. These data complement an existing L-band observation (856–1711 MHz; de Gasperin et al. 2022), enabling a detailed multi-band rotation measure (RM) analysis.

By combining the UHF and L-band datasets, we derive high-resolution spectral index and RM maps, which are essential for studying the magnetic field structure and evolution in the shocked ICM with unprecedented detail. This study highlights the importance of resolved RM synthesis across a broad frequency range, a capability that will be dramatically enhanced with SKA.

Moreover, the cluster's radio halo is clearly detected for the first time, revealing its full extent and morphology. We present the first spectral analysis of the halo emission, which supports a scenario of turbulence-driven particle reacceleration.

This study demonstrates the power of SKA pathfinder observations to probe cosmic magnetism and non-thermal phenomena in the ICM. The techniques and results presented here pave the way for the next-generation studies of cosmic magnetism and non-thermal processes in galaxy clusters with SKA.

Topics:

Galaxy Clusters & LSS (relativistic particles and magnetic fields)

32

ViCTORIA project: the MeerKAT Virgo Cluster Survey

Author: Alessandro Benati[1]

Co-authors: Angelina Spasic [2]; Francesco De Gasperin [1]; Marcus Brüggen

[1] *Istituto Nazionale di Astrofisica (INAF)*

[2] *University of Hamburg*

Corresponding Author: a.benati@ira.inaf.it

The ViCTORIA (Virgo Cluster multi-Telescope Observations in Radio of Interacting galaxies and AGN) project is a unique multi-frequency radio survey of the Virgo cluster, combining LOFAR-LBA, LOFAR-HBA, and MeerKAT data to achieve unprecedented depth, resolution, and spectral coverage. The Virgo cluster, the closest rich cluster in the Universe, is a key target for understanding galaxy evolution, AGN feedback, and the role of the environment in shaping galaxy properties.

In this talk I will present the MeerKAT Virgo Cluster Survey, carried out in L band (856–1712 MHz). This dataset offers a full-polarisation, wide-band coverage over 112 deg^2, with 64 observations and a total number of pointings of 320. With a sensitivity of $7\mu\mathrm{Jybeam}^{-1}$ at the nominal resolution of 7.6 \text{″}, and complemented by a dedicated peeling strategy to mitigate the dynamic range limitations introduced by Virgo A (M87), the MeerKAT Virgo Cluster Survey enables high-fidelity imaging of diffuse and compact radio sources, including hundreds of cluster galaxies and low-surface-brightness features such as ram-pressure stripped tails and intra-cluster filaments.

To process such a large and complex dataset, we developed a dedicated data reduction pipeline, optimised for full-polarisation, wide-band imaging and tailored to the specific challenges posed by the Virgo Cluster. This pipeline is designed to ensure uniformity, scalability, and reproducibility, which are key requirements in the SKA era, and integrates advanced strategies for direction-dependent calibration and dynamic range enhancement.

This contribution will present the initial scientific results from the MeerKAT Virgo Cluster Survey, which aims to derive polarised images, including RM synthesis of cluster galaxies and AGN, spectral index mapping between HBA and MeerKAT frequencies, and perspectives for probing spectral curvature across the entire 42–1712 MHz frequency range. By bridging the LOFAR and MeerKAT regimes, ViCTORIA exemplifies the synergistic science enabled by SKA precursors, paving the way for SKA-MID surveys of galaxy clusters and diffuse emission. This project contributes directly to the preparation of SKA science by testing data analysis strategies, building collaborations, and offering a high-legacy, multi-frequency dataset of strong relevance to the SKA science case.

Topics:

Galaxy Clusters & LSS (relativistic particles and magnetic fields)

33

MeerKAT observations of galaxy clusters

Author: Andrea Botteon[1]

[1] *INAF-IRA*

Corresponding Author: andrea.botteon@inaf.it

Diffuse radio emission is now observed in many galaxy clusters. Depending on the morphology and properties of the emission, such sources are generally classified as radio (mini) halos, relics, and bridges. These synchrotron sources traces relativistic particles and magnetic fields that are accelerated and amplified in the intra-cluster medium (ICM) through a complex chain of mechanisms, which convert kinetic energy from cluster-scale motions down to the particle scale.
In this talk, I will present recent results from MeerKAT observations of galaxy clusters in different dynamical states, all characterized by the presence of diffuse radio emission in the ICM. In particular, I will highlight what is the step forward led by these new observations and discuss the likely formation scenarios of the sources presented.

Topics:

Galaxy Clusters & LSS (relativistic particles and magnetic fields)

34

The SKA view of AGN feedback in galaxy groups

Author: Thomas Pasini[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: thomas.pasini@inaf.it

Over the last two decades, significant progress has been made in understanding the physical processes observed in galaxy clusters. AGN feedback has emerged as the leading explanation for several longstanding astrophysical questions, including the origin of scaling relations between supermassive black holes and their host galaxies, as well as the discrepancy between the predicted and observed baryonic content that has condensed into stars. Feedback mechanisms also play a crucial role in galaxy evolution, and recent simulations have shown that cosmological models need accurate prescriptions of AGN feedback to correctly predict the properties and distributions of galaxies and of the largest-scale structures

While feedback in these massive clusters is well studied, progress in the lower-mass regime of galaxy groups has been limited by observational constraints. Recently, SKA precursors and pathfinders such as LOFAR, uGMRT, and MeerKAT have obtained some initial interesting results. Examples include signatures of AGN overheating, which can significantly counteract the ongoing cooling of the Intra-Group Medium (IGrM); groups with largely evacuated environments due to powerful and prolonged feedback activity, something that has never been observed in clusters and which prevents the formation of a cool core; and remnant plasma detectable only at very low frequencies, displaced by large-scale sloshing motions, that demonstrate how the evolution of groups and AGN can strongly affect each other.

This talk will go through these recent advances, emphasising the current state of the art and the cosmological significance of galaxy groups while identifying gaps in our understanding. Furthermore, it will explore how SKA promises to close these gaps and revolutionise the field, offering new insights into the complex interactions that shape galaxy group evolution and dramatically enhancing the statistical power of future studies.

Topics:

Galaxy Clusters & LSS (relativistic particles and magnetic fields)

35

The LOFAR Decameter Sky Survey: status and lessons for SKA-Low

Author: Christian Groeneveld[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: christian.groeneveld@inaf.it

The largely unexplored decameter radio band (10-30 MHz) provides a unique window for studying a range of astronomical topics, such as auroral emission from exoplanets, low-energy cosmic ray electrons, and the physics of free-free absorption. The scarcity of low-frequency studies is mainly due to the severe perturbing effects of the ionosphere. Correcting for the ionosphere is challenging as it changes rapidly in time and across the sky at these extremely low frequencies. Building upon previous successes at higher frequencies, we present a calibration strategy that can correct for the ionosphere in the decameter band. We apply this to a night-time observation from the Low Frequency Array (LOFAR) between 16–30 MHz, to evade the majority of radio frequency interference. This allows us to survey a 305 square degrees region of sky at a resolution of 45 arcsec, achieving a sensitivity of 12 mJy/beam. This represents over an order of magnitude improvement in terms of sensitivity and resolution compared to previous decameter band observations, emphasising the large discovery potential of our data. As LOFAR is a direct SKA-Low telescope pathfinder, the development of a pipeline at such low frequencies is critical for calibration of future SKA-Low observations, especially near the lower end of its frequency coverage (~50 MHz).

Topics:

Galaxy Clusters & LSS (relativistic particles and magnetic fields)

36

Detecting of the HI auto-power spectrum with MeerKAT data

Author: Matilde Barberi Squarotti[1]

[1] *Università degli Studi di Milano*

Corresponding Author: matilde.barberi@unimi.it

Neutral hydrogen (HI) intensity mapping is emerging as a revolutionary probe of the Large Scale Structure of the Universe and the MeerKLASS collaboration (MeerKAT Large Area Synoptic Survey) is currently running precursor analyses aiming to test the single-dish technique for mapping the cosmological 21cm signal using MeerKAT data. This signal, originating from the line emission at 1420MHz of HI permeating the cosmic web, is extremely weak compared to astrophysical contaminants, making foreground removal one of the major challenges to tackle.
I will present the analysis of 2021 MeerKAT L-band data, focusing on foreground cleaning strategies and, most notably, on the implementation of internal cross-correlations to mitigate noise and systematics. This technique is enabling the first-ever detection of the cosmological HI signal at large scales that didn't require an external spectroscopic galaxy datasets for cross-detection. The results already obtained show robustness against a variety of consistency tests performed and consistency with previous constraints coming from the cross-correlation of previous MeerKAT data and WiggleZ galaxies. The recent results have demonstrated the feasibility of the single-dish technique for probing the largest scales of the cosmic web with HI intensity mapping, paving a new way for cosmology, and the SKAO will realise the full potential of this technique emerging as a cutting-edge instrument for advancing our understanding of the Universe.

Topics:

Cosmology

37

Dust evolution in protoplanetary disks with SKA and precursors

Author: Melanie Isabelle Monique Armante[1]

Co-authors: Antonella Natta ; Davide Fedele [1]; Leonardo Testi [2]

[1] *Istituto Nazionale di Astrofisica (INAF)*

[2] *Dipartimento di Fisica e Astronomia, Università di Bologna*

Corresponding Author: melanie.armante@inaf.it

Among the variety of structures that can be observed at millimeter and sub-millimeter wavelength within disks, some present an inner cavity depleted from gas and dust. Such disks are called transitional disks (TDs). Cavities, are generally attributed to the formation and evolution of one or more giant planets (as it is the case for PDS 70), severing the connection between the outer and inner disks, which is then rapidly depleted by accretion onto the star. At the same time, these planets are modifying the disk gas pressure profile leading to the creation of a pressure trap and, consequently, a ring-like structure in the dust distribution, as large grains are confined as they drift in from the outer disk.
This scenario, thus implies that the planets inside the ring greatly stops the exchange of pebbles between the outer and the inner part of the disk. Even though, observations show that material continues to pass through the planet to the star, the stellar mass accretion in TDs is lower than for full disks of same age or mass. On top of it, since large grains are trapped within the ring, only small grains and gas can filtrate through the cavity, failing to fully explain the large amount of material needed by the central star. As a result, within the inner cavity, no significant dust emission at (sub-)millimeter wavelength should be observe. On the contrary, a compact millimeter emission it observed for about 50% of TDs by ALMA, as it is the case for the TD surrounding CQ Tau, a nearby, intermediate mass pre-main sequence star of spectral type F2.

As of today, it is not clear if such compact emission is due to the presence of pebbles or whether it is due to non-thermal emission related, e.g., an ionized wind. To quantify this possibility, we performed a detailed multi-wavelength analysis to study the emission in the inner disk of CQ Tau, combining a large set of sensitive and high angular resolution continuum observations from ALMA and VLA, from 0.87 mm to 6 cm. Our goal is to try and separate dust and gas emission in the inner region of this system.
We present the results and conclusions of a detailed spectral index analysis, as a first attempt to characterize the nature of the emission in every part of the disk, extrapolate the free-free emission present and then finally separate between this emission and dust thermal emission for CQ Tau. Even though these results are very interesting, we noticed that they are limited by either the resolution of the centimetric observations, by the number of observations or the optical depth of the emission of the millimetric observations, which gap could be filled by the use of SKA data. Finally, we present further initial attempts to extend these results to a broader sample of TDs.

Topics:

Cradle of Life & Our Galaxy

38

Evolution of large-scale magnetism through SKA and its precursors

Author: Gabriella Di Gennaro[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: gabriella.digennaro@inaf.it

Diffuse radio emission in galaxy clusters has been established to be linked with the presence of (re-)accelerated particles (i.e. cosmic rays, CRs) and magnetic fields (B). In the last years, thanks to the advent of highly-sensitive radio telescopes such as LOFAR and MeerKAT, the detection of diffuse radio emission has become possible also in clusters at high redshift (z>0.6). This allowed a first investigation of evolution of magnetic fields in the largest virtualised structures in the Universe, at the time of their formation. However, a complete statistical analysis is still missing. I will present the current knowledge on the cosmic evolution of magnetic fields, and the future window that SKA and its precursors will open. These new observations will provide crucial insights on the properties of the non-thermal component in the high-z cluster population.

Topics:

Galaxy Clusters & LSS (relativistic particles and magnetic fields)

39

Revealing the Magnetic Landscape of Galaxy Clusters with SKA

Author: Francesca Loi[1]

[1] *INAF-OAC*

Corresponding Author: francesca.loi@inaf.it

Recent observations of diffuse radio sources in galaxy clusters, along with the detection of polarized emission from the tails of a jellyfish galaxy, underscore the pivotal role of intracluster magnetic fields in governing the physical conditions of these environments and influencing the evolution of cluster galaxies. Understanding the properties of these fields is crucial for comprehending the physical processes occurring in galaxy groups and clusters, as well as the evolution of the embedded sources. The upcoming Square Kilometre Array (SKA) telescopes promise to transform this field through their unprecedented sensitivity, high angular resolution, and broad frequency coverage. These capabilities will enable detailed analysis of the Rotation Measure (RM) grid, providing a deeper understanding of intracluster magnetic fields.
In this talk, starting with the unprecedented results of the MeerKAT Fornax Survey in polarization (~80 polarized sources/deg^2), I will discuss the impact of the SKA-mid telescope in enhancing our understanding of cluster physics and galaxy evolution, critically examining both the strengths and limitations of the proposed survey design.

Topics:

Galaxy Clusters & LSS (relativistic particles and magnetic fields)

40

MACS J1752+4440 across the spectrum: from SZ signatures to radio polarization

Author: Silvia Cocchi[1]

Co-author: Francesca Loi [2]

[1] *Istituto Nazionale di Astrofisica (INAF)*

[2] *INAF-OAC*

Corresponding Author: silvia.cocchi@studenti.unipd.it

Within the filamentary web that constitutes the large-scale structure of the Universe, merging galaxy clusters represent some of the most energetic events since the Big Bang. A multi-wavelength approach-combining X-ray, optical, radio, and Sunyaev-Zel'dovich (SZ) observations-is essential to unravel their physics, trace their evolution, and assess the role of magnetic fields in shaping the intracluster medium (ICM).
The upcoming SKA1-Mid, with its Band 2 (0.95-1.76 GHz) and Band 5b (8.3-15.3 GHz) receivers will provide a significant improvement in this field, enabling high-sensitivity polarimetric studies at low frequencies and SZ–polarimetry synergy at higher frequencies.
In this context, I will present an important precursor study: a multi-frequency investigation of the galaxy cluster MACS J1752+4440, known to host a double radio relic system, using new observations with the Sardinia Radio Telescope (SRT) at 18.6 GHz and archival JVLA data at 1.6 GHz.
These data enabled a joint investigation of the system's total intensity, polarization, and SZ signatures. Importantly, the SRT observations provided the first detection of the SZ effect at $\sim$20 GHz in this cluster, directly probing the scattering of CMB photons by hot electrons in the ICM. Meanwhile, the JVLA data at 1.6 GHz allowed for a Rotation Measure (RM) synthesis analysis, yielding an RM profile and insights into the depolarization properties of the relics.
By combining the SZ-derived density profile with the RM measurements, we estimated an average line-of-sight magnetic field strength of $\sim$2 μG. This result highlights the power of combining radio polarimetry with SZ observations to jointly probe the non-thermal and thermal components of the ICM in merging galaxy clusters.

Topics:

Galaxy Clusters & LSS (relativistic particles and magnetic fields)

41

BL Lac or FR I? A MeerKAT spectropolarimetric analysis of PKS 2316-423

Author: Fabrizio Gandossi[1]

Co-author: Francesca Loi [2]

[1] *Istituto Nazionale di Astrofisica (INAF)*

[2] *INAF-OAC*

Corresponding Author: fabrizio.gandossi@studenti.unipd.it

Active Galactic Nuclei are among the most powerful phenomena in the Universe. They play a crucial role in the formation and evolution of galaxies and, in the case of the most powerful sources, in shaping the properties of galaxy clusters.

In this work I analyse a BL Lac object, named PKS 2316-423, located at the centre of the galaxy cluster Abell S1111, using MeerKAT L-band observations. Despite its classification as a blazar, this source exhibits a complex morphology, with some characteristics typical of an FR I radio galaxy. It displays a bright compact core together with very diffuse and filamentary extended emission ($\sim$ 400 kpc), which is revealed thanks to the high sensitivity and resolution of MeerKAT.

By performing an in-band spectral mapping analysis, I determined for the first the spectral index on point-by-point with unprecedented resolution in literature. The spectrum steepens from $\alpha \approx -0.2$ in the core to $\alpha \approx -1.8$ in the outermost regions of the lobes, with $\propto \nu^{\alpha}$. Fitting a Jaffe-Perola model to these results yields radiative ages ranging from $\sim$ 25 to 120 Myr.

I performed a polarimetric analysis that has been crucial to provide additional insights into the source properties and the interaction between the jets and the surrounding intracluster medium. The rotation measure synthesis results show evidence of the Laing–Garrington effect, which further contribute in the characterization of the source and that can be used to determine the strength and structure of the magnetic field in the environment in front of the source.

These results demonstrate the unique capability of MeerKAT to probe faint extended emission from AGN, and highlight the potential of the future SKA to push such studies to even higher sensitivity and resolution.

Topics:

Galaxy Evolution & AGN

42

Small but Mighty: Unveiling Low-Power Radio AGN with the SKA

Author: Ranieri Diego Baldi[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: ranieri.baldi@inaf.it

Low-power radio active galactic nuclei (AGN) with radio luminosities below 10^{23} W Hz^{-1} represent a numerically dominant but still poorly understood population, crucial for unveiling the full impact of radio-mode feedback on galaxy evolution. Unlike classical FR I/II sources, these faint AGN often lack prominent extended jets and lobes, making them elusive in current surveys and raising open questions about their duty cycle, their connection to host galaxy properties, and their role in regulating star formation through small-scale energy injection. The Square Kilometre Array (SKA) will provide a breakthrough in this field: SKA-Mid and SKA-Low continuum surveys will deliver an unprecedented census of low-luminosity radio AGN across cosmic time, reaching μJy sensitivities and characterizing their spectral and morphological properties, while SKA-VLBI will resolve compact cores and parsec-scale jets, disentangling nuclear activity from star formation in their hosts. I will discuss how these capabilities will allow us to constrain the space density, host demographics, and feedback signatures of low-power AGN, with particular emphasis on the compact FR0 population, and outline the key scientific opportunities for the Italian community in exploiting SKA and its precursors to probe the faint end of the radio-loud AGN population.

Topics:

Galaxy Evolution & AGN

43

The ionised Milky Way: the SKA survey of the continuum radio in the Galactic Plane

Authors: Adriano Ingallinera[1]; Alessio Traficante[1]; Alice Nucara[1]; Chiara Mininni[2]; Claudio Codella[1]; Corrado Trigilio[1]; Eleonora Bianchi[3]; Francesco Cavallaro[1]; Giovanni Sabatini[3]; Grazia Maria Gloria Umana[1]; Linda Podio[1]; Milena Benedettini[1]; Sergio Molinari[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

[2] *INAF-IAPS*

[3] *INAF - Osservatorio Astrofisico di Arcetri*

Corresponding Author: alessio.traficante@inaf.it

Our Milky Way is a unique laboratory to investigate the (massive) star formation mechanisms with a detail that cannot be reached in any other galaxy. These multi-scale processes are regulated by a complex interplay between gravity, turbulence and feedback which vary from region to region. Large surveys of the Galactic Plane (GP) have been proved as a particularly powerful tool to investigate such mechanisms on a statistically significant sample of objects in different environments. GP surveys in the FIR/sub-mm with Herschel revealed and characterized hundreds of thousands of parsec-scales clumps. In combination with surveys of dense gas tracers such as MALT90 or SEDIGISM we were able to characterize the dynamics of hundreds of these objects across the Galaxy. Thanks to recent surveys performed with ALMA we were now able to observe a thousand of star-forming clumps at ~1500AU resolution, revealing how the fragmentation properties may vary across different Galactic environments. What is still missing to get a more complete picture of the star-formation process is to understand the feedback mechanisms in various star-forming complexes.

SKA-Mid will provide for the first time the opportunity to map the continuum emission from the ionised gas with unprecedented sensitivity and angular resolution in a large portion of the GP. These data will provide the basis to estimate the radio emission associated with jets, outflows and expanding HII regions, the main feedback mechanisms in place in young protoclusters.

This SKA project combined with ancillary GP surveys will enable a first comprehensive picture of the interplay between gravity, turbulence and feedback across various environments of our Galaxy in thousands of massive regions. Such survey will have a legacy value for years to come, by providing at the same time a unique database of radio continuum emission associated with newly forming HII regions, large-scale radio filaments, supernovae expanding shells and planetary nebulae. We will finally discuss how the capabilities of the AA* and AA4 configurations will guarantee surveys of the GP able to reach the weakest star-forming regions at more than 10 kpc away from us.

Topics:

Cradle of Life & Our Galaxy

44

Probing clusters outskirts: what can megahalos tell us?

Author: Matteo Cianfaglione[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: matteo.cianfaglione@inaf.it

Recent LOFAR observations of massive galaxy clusters revealed the presence of a new type of large scale diffuse radio emission, known as megahalo, extending up to clusters outskirts (Cuciti et al. 2022, Nature). Megahalos span scales of ~3-4 Mpc and, due to their extension, allow us to probe cluster volumes that are 30 times larger than the ones occupied by radio halos. This means that with more sensitive studies, we will be able to study in depth the non-thermal components (cosmic rays and magnetic fields) in the peripheries of galaxy clusters. To this day, only 4 megahalos have been detected and confirmed, while their origin remains unknown. Thanks to the unprecedented sensitivity of the SKA telescopes, we will be able to detect more of these sources. In this talk, I will present the new megahalos detected with LOFAR and the first detection of a megahalo using MeerKAT, showcasing the abilities of SKA pathfinders and precursors, and highlighting the advantages that the SKA telescopes will give us in the search and study of these sources.

Topics:

Galaxy Clusters & LSS (relativistic particles and magnetic fields)

45

Tracing magnetic fields in the cosmic web: insights from ASKAP and prospects with SKA

Author: Chiara Stuardi[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: stuardi@ira.inaf.it

Magnetic fields have been detected so far through Faraday rotation in individual galaxy clusters and in stacked cosmic filaments; however, a direct measurement in individual filaments remains challenging. In this talk, I present the first attempt to constrain the magnetic field in the ~13 Mpc inter-cluster filament connecting Abell 3667 and Abell 3651 (z ~ 0.06), recently detected in X-rays by eROSITA. Using the Polarisation Sky Survey of the Universe's Magnetism (POSSUM) performed with ASKAP, I analysed the Rotation Measure scatter of background polarised sources across the filament region. Our results suggest a marginal detection of the filament, leading to an upper limit to its magnetic field strength. While current data do not allow a firm detection, these results provide the first Faraday-based constraint on magnetic fields in an inter-cluster bridge, in line with theoretical predictions. Moreover, I will discuss how the upcoming SKA will revolutionise this type of study, enabling robust measurements of magnetic fields in the cosmic web with unprecedented sensitivity and resolution.

Topics:

Galaxy Clusters & LSS (relativistic particles and magnetic fields)

46

Forecasting AA* and AA4 SKA observations with a 2Gpc 21cmFASTv4 simulation

Author: Daniela Breitman[1]

[1] *Scuola Normale Superiore (SNS)*

Corresponding Author: daniela.breitman@sns.it

The cosmic dawn (CD) of the first luminous objects and eventual epoch of reionisation (EoR) of the intergalactic medium (IGM) remain among the greatest mysteries in modern cosmology. The 21-cm line is one of the most powerful probes of these crucial moments in the history of the Universe, providing a clean window into both cosmology and astrophysics. It has unmatched potential, ultimately able to provide us with a 3D map of more than half of our observable Universe, as expected with the SKA. With its upcoming science verification phase, it is especially important to quantify its detection potential for CD/EoR science. The first step to forecasting the SKA observation potential is to produce a large mock observation with state-of-the-art cosmology and astrophysics.

In this work, we perform a 2 cGpc simulation, *the largest simulation ever made with a semi-analytical model with 1.5 cMpc resolution*, as the 2025 installment of the Evolution of 21-cm Structure (EOS) project with the new v4 release of 21cmFAST. EOS25 improves over the previous releases with the inclusion of a discrete source model based on stochastic sampling of conditional mass functions and semi-empirical galaxy relations which only became available with 21cmFASTv4. All summary observables from EOS25 are consistent with current observations. In particular, the halo catalogs

produced by EOS25 are consistent with those from JWST after applying the same selection criteria.

We then use 21cmSense to forecast SKA sensitivities for the AA* and AA4 configurations as well as 18m and 12m substation layouts. Using EOS25 and our simulated sensitivities for the mock observation, we perform a set of inferences with the publicly available 21cmEMU emulator suite. We find that SKA AA* will allow us to constrain the EoR history to the percent-level, providing us with the reionisation midpoint within 0.03. We also find that we can constrain the 21-cm PS to over 7σ at redshifts less than 8. We recover the Thomson scattering optical depth to the CMB (τ_e) with a 20 tighter 1σ than Planck18. Finally, our inferences show that for CD/EoR science, AA* is just as constraining as AA4.

Topics:

Epoch of Reionization and Cosmic Dawn

47

Unveiling cocoon emission in relativistic type Ic broad-line supernovae

Author: Luca Izzo[1]

Co-authors: Aprajita Hajela [2]; Fabio De Colle [3]; James Leung [4]; Katie Auchettl [5]; Keiichi Maeda [6]

[1] *Istituto Nazionale di Astrofisica (INAF)*

[2] *DARK/NBI*

[3] *UNAM*

[4] *University of Toronto*

[5] *University of Melbourne*

[6] *Kyoto Univ.*

Corresponding Author: luca.izzo@inaf.it

Type Ic broad-line supernovae are energetic events requiring an additional energy source to explain their high kinetic energy, likely driven by a relativistic jet from a rapidly rotating compact remnant. The jet generates a cocoon that influences supernova properties, with signatures predominantly detectable at radio frequencies soon after the explosion. In this talk, we will share findings from our pathfinder program, including a radio supernova with a late-time radio rebrightening inconsistent with circumburst medium shell interaction, showing an unprecedented radio spectral evolution. Despite valuable insights, the program's sensitivity is limited to <200 Mpc events. The SKA order-of-magnitude sensitivity improvement is essential for expanding our understanding, from individual cases to a comprehensive population-wide analysis on the role of the jet in powering these energetic stellar explosions, as well as the processes associated with the formation of the cocoon. We will discuss these discoveries and the promising future of this radio transient research with SKA.

Topics:

Transients & GW follow-up

48

Carbon chain diversity in L1544 and IRAS 16293-2422: an astrochemical pathfinder study for the SKAO

Author: Lisa Giani[1]

Co-authors: Eleonora Bianchi [2]; Anthony Remijan ; Claudio Codella [1]; Giovanni Sabatini [2]; Linda Podio [1]; Cecilia Ceccarelli ; Marta De Simone ; Nadia Balucani ; Paola Caselli ; Eric Herbst ; Francois Lique ; Silvia Spezzano ; Charlotte Vastel ; Brett McGuire

[1] *Istituto Nazionale di Astrofisica (INAF)*

[2] *INAF - Osservatorio Astrofisico di Arcetri*

Corresponding Author: lisa.giani@inaf.it

Astrochemical observations have revealed a surprisingly high level of chemical complexity, including long carbon chains, in the earliest stages of Sun-like star formation. The origin of these complex species and whether they undergo further growth, possibly contributing to the molecular complexity of planetary systems, remain open questions.
We present recent observations performed using the 100-m Green Bank Telescope in the prestellar core L1544, and the protostellar system IRAS 16293–2422. In L1544, we detected various complex carbon-bearing species, including C_2S, C_3S, C_3N, c-C_3H, C_4H and C_6H, complementing previously reported emission of cyanopolyynes. In IRAS 16293–2422, we detected c-C_3H and, for the first time, HC_7N. Thanks to the high spectral resolution, we refine the rest frequencies of several c-C_3H and C_6H transitions. We perform radiative transfer analysis, highlighting a chemical difference between the two sources: IRAS 16293–2422 has column densities 10 to 100 times lower than L1544. We perform astrochemical modeling, employing an up-to-date chemical network with revised reaction rates. The predicted abundances of cyanopolyynes and polyynyl radicals decrease with molecular size, in agreement with observations. However, the models underestimate the abundances of cyanopolyynes longer than HC_5N, by up to two orders of magnitude. Current models do not support the hypothesis that elevated cosmic-ray fluxes or strong UV irradiation enhance cyanopolyyne production. This discrepancy suggests that the dominant neutral–neutral formation routes currently included in the network are incomplete. We propose that additional ion–molecule reactions are crucial for the formation of these species. Developing a more comprehensive chemical network for long carbon chains is essential for accurately interpreting present and future observations.

Topics:

Cradle of Life & Our Galaxy

49

Unveiling the spectral properties of radio halos in the Galaxy Clusters of the LOFAR Sky Survey

Author: Koushika Sri Lakshmi Srikanth[1]

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

[1] *IRA-INAF Bologna*

[2] *INAF-IRA*

[3] *Bologna University & INAF*

[4] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: s.koushika@ira.inaf.it

Radio halos are diffuse, large-scale radio sources with low surface brightness situated in the central region of galaxy clusters, extending over megaparsec scales. They are believed to originate from cosmic rays re-accelerated by merger-driven turbulence by second-order Fermi mechanism. The turbulent re-acceleration model anticipates a substantial population of radio halos with very-steep spectra ($\alpha > 1.5$, where $S_\nu \propto \nu^{-\alpha}$) and a correlation between the turbulent energy, linked to the cluster merger event, and the resulting radio synchrotron spectral shape. However, this hypothesis has not been extensively tested due to limited sensitive low-frequency radio observations. In this

talk, I will present the first statistical analysis of the spectral properties of radio halos using a complete sample by combining LOFAR and uGMRT data. The project focuses on a complete sample of 45 radio halos in the Second Data Release of the LOFAR Two-meter Sky Survey (LoTSS-DR2, 150 MHz), which was recently followed up at uGMRT (Band04, 650 MHz). In this talk, the first results will be highlighted based on a fully analyzed subsample of 30 radio halos, discussing the connection between their spectral properties and the dynamical state of the hosting clusters. Finally, I will explore how radio halo properties depend on cluster mass and redshift, discuss the implications for the turbulent re-acceleration model, and emphasize the relevance of these findings for future observations with the SKA. These findings lay the groundwork for interpreting the much larger and more diverse samples expected from future SKA surveys, which will significantly enhance our understanding of the origin of radio halos.

Topics:

Galaxy Clusters & LSS (relativistic particles and magnetic fields)

50

The Northern Cross Fast Radio Burst project: status update and future perspectives

Author: Maura Pilia[1]

Co-author: Gianni Bernardi [1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: maura.pilia@inaf.it

Fast Radio Bursts are millisecond-long, bright (typically 1-100 Jy) radio flashes of (mostly) cosmological origin (up to z ~ 2.1!). At the time of writing, close to a thousand events have been published, with a large range of properties in terms of fluences, spectra, time smearing and characteristics of the host galaxies - when localized. Their origin remains indeed largely debated, although an unmistakable connection between magnetars and (some) FRBs has been established recently. In the future, the SKA will provide observability over two frequency decades with simultaneous, superb localization, i.e. FRB cosmology.
In this talk I will review the Northern Cross FRB project, the ongoing effort to equip and use the Northern Cross (NC), the oldest Italian radio telescope, to observe FRBs. I will present the project's main results, highlighting the studies on known FRB repeaters and the population studies within our Galaxy and in a sample of star-forming nearby galaxies. Finally I will describe the future path, including the equipment of the 64 cylinders of the North-South arm and the upgrade of the East-West arm, which will lead to a low frequency telescope similar to CHIME and, therefore, an effective FRB survey machine that will be able to give our community a leading role in the SKA era.

Topics:

Transients & GW follow-up

51

High-frequency tecno signatures search with MeerKAT Band 5B

Author: Andrea Melis[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: andrea.melis@inaf.it

MeerKAT is an array composed of 64 13.5-m dishes and represents the main precursor of the SKA-mid radio telescope to which will be incorporated to form the final 197 antennas array envisaged for SKA-Mid. MeerKAT is fully involved in the SETI (Search for ExtraTerrestrial Intelligence) project, specifically it is part of the large Breakthrough Listen telescopes network, which also includes the Sardinia Radio Telescope. So far, SETI searches have been mostly carried out at low/medium frequencies, current SETI trend is to widen the search at higher spectral frequency windows and the available instrumentation at the MeerKAT facility does not allow us to go beyond the S-Band (1.75 - 3.5 GHz). In addition, searches are carried out in commensal/piggyback mode only, i.e. no specific time is reserved for SETI studies to cover sky regions that might supposedly host life. The band 5 project, with which receivers operating in the 8.3 - 15.4 GHz band will be soon installed at MeerKAT, will overcome this limitation. In the context of this enhancement and the needed time to commission both technically (digitizers, receivers, compressors, software etc) and scientifically the whole instrument, SETI targeted time will also be allocated to conduct techno-signatures studies at nearby stars with exoplanetary systems that could potentially be interesting to host (also) intelligence life.

This talk will present the scientific motivations for SETI searches in Band 5B with MeerKAT. This frequency range allows deep surveys of the Galactic Center at largely unexplored frequencies, and targeted observations of M-dwarf stars, where spectral broadening of narrowband signals is less severe than at lower frequencies. I will also outline the collaboration between INAF and the Breakthrough Listen team to upgrade the current SETI hardware–software infrastructure at MeerKAT, enabling wide-band, real-time techno signature searches. The new SETI instrument will be highly flexible and fully compatible with the SKA-mid array.

Topics:

Technology & IT

52

Non-thermal filaments in galaxy clusters with LOFAR-VLBI

Author: Emanuele De Rubeis[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: emanuele.derubeis2@unibo.it

New generations of interferometers are revealing a wealth of spectacular filaments in the surrounding of radio galaxies, mostly residing in group/cluster environment, whose origin is still unknown. Filamentary structures present new opportunities for studying the physical processes in the intracluster medium, including their magnetic structures and the propagation of cosmic rays. Given the steep radio spectra shown by these structures, deep, low-frequencies observations are necessary to detect them. In this talk, I will present the deepest (56 hours) LOFAR-VLBI observations of filaments in the merging galaxy cluster Abell 2255 at 144 MHz. Going down to sub-arcsecond, we detected and resolved for the first time several filamentary structures related to the tailed cluster radio galaxies, characterizing their morphology and emission at unprecedentedly high-resolution. These observations prove the potentiality of LOFAR-VLBI for studying these new emerging radio phenomenon. I will then present high-resolution spectral studies, that were possible combining LOFAR-VLBI data with the higher frequencies ones from uGMRT and VLA. With high-resolution (2-3 kpc), we can disentangle the spectral properties of the filaments to study their nature and the interplay between the radio galaxy and the turbulent cluster environment.
I will discuss several interpretation scenarios regarding the origin of the filamentary emission, and present possible opportunities about the long baselines in SKA-Low.

Topics:

Galaxy Clusters & LSS (relativistic particles and magnetic fields)

53

The EMU Cosmology Project

Author: Benedict Konrad Wilhelm Bahr Kalus[1]

Co-authors: Stefano Camera [2]; Daniela Carollo [1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

[2] *Università degli Studi di Torino, Italy*

Corresponding Author: benedict.bahrkalus@inaf.it

The Evolutionary Map of the Universe (EMU) is a radio continuum survey that, using the Australian SKA Pathfinder (ASKAP), aims to map the entire Southern Sky by 2028 and is expected to detect approximately 20 million extragalactic radio objects. Measuring the distribution of radio continuum galaxies on the sky provides a fast and accessible probe of the distribution of matter in the Universe, covering more than 12 billion years of cosmic history, which in turn can be used to learn about the initial conditions, the physics of dark matter, and the nature of the mysterious dark energy. I will give a status update of the first EMU Main Survey Cosmology measurements.

Topics:

Cosmology

54

Gamma-ray Bursts and Kilonovae from Gravitational Wave Events

Author: Marcello Giroletti[1]

Co-authors: Alberto Colombo [1]; Giancarlo Ghirlanda [1]; Om Sharan Salafia [1]; Stefano Giarratana [1]; Susanna Vergani

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: marcello.giroletti@inaf.it

The detection of gravitational waves (GW) from binary black holes in 2015 and of the discovery of associated GW and electromagnetic (EM) radiation from the binary neutron star merger GW 170817 have opened a new era for astrophysics. We are currently in the fourth observing cycle of gravitational interferometers, with the participation of LIGO, Virgo, and KAGRA, and a new run is currently planned to start in 2028. In the 2030's, next generation gravitational interferometers from ground and space will come into operation (Einstein Telescope, Cosmic Explorer, LISA).

The potential for joint GW and EM observation, considering also the search for kilonovae in large optical surveys, is immense; and so are the challenges. When it comes to radio observations, connected interferometers and VLBI arrays have already shown their relevance to constrain the nature of the ejection in the case of GW 170817. EM emission from gamma-ray burst (GRB) afterglows (both on- and off-axis) can remain detectable at radio wavelengths for much longer times than in any other band. This allows the characterisation of the evolution of the systems with better precision, piercing the structure of GRB jets, and possibly also the detection of misaligned jets, once the velocity has become non relativistic.

As a standalone interferometer, the SKAO will have sensitivity and field of view suitable to complement the search for GW counterparts during O5 and later, and to monitor the light curves of any confirmed counterpart longer than any other instrument. Moreover, as an element of a VLBI array, it would contribute the sensitivity to constrain the parameter of the structural evolution for the closest events.

We will give an overview of the current and future observational landscape, of the primary questions that the SKAO will help addressing, and of the role of the Italian community in this rich framework.

Topics:

Transients & GW follow-up

55

The emerging population of high-energy radio galaxies

Author: Gabriele Bruni[1]

Co-authors: Francesca Panessa [2]; Manuela Molina [2]; Marcello Giroletti [2]; Angela Malizia [2]; Loredana Bassani [3]; Massimo Persic [4]

[1] *INAF - Istituto di Astrofisica e Planetologia Spaziali*

[2] *Istituto Nazionale di Astrofisica (INAF)*

[3] *INAF - OAS*

[4] *INAF - Osservatorio di Padova*

Corresponding Author: gabriele.bruni@inaf.it

The release of the 4th Fermi/LAT AGN catalogue, based on more than a decade of observations, has confirmed that blazars dominate the GeV sky, accounting for 98% of the detected sources. The remaining 2% includes other AGN classes such as radio galaxies, narrow-line Seyfert 1 galaxies, compact steep-spectrum radio sources, and steep-spectrum radio quasars. The advent of new large-scale radio surveys, such as the VLA Sky Survey (VLASS) and the Rapid ASKAP Continuum Survey (RACS), carried out with the latest generation of radio telescopes, has opened up new opportunities for the classification and study of extragalactic gamma-ray sources, particularly misaligned AGN. The improved sensitivity and angular resolution of these surveys now enable a more accurate morphological and spectral classification, leading to the discovery of an emerging population of radio galaxies emitting in the GeV regime. Further objects of this class are expected to be identified in the near future with the advent of the Square Kilometre Array (SKA), which will significantly enrich the GeV sky.

This talk will discuss the prospects with SKA, to be presented in a chapter of the next SKA White Book. Specifically, SKA-Low will allow us to probe the extended lobe emission at low frequencies, while SKA-Mid will provide the frequency coverage required for spectral energy distribution (SED) studies and synchrotron ageing analyses. Finally, SKA-VLBI will resolve the innermost regions of AGN cores, unveiling potential signatures of jet reorientation or the onset of a new activity phase.

Topics:

Galaxy Evolution & AGN

56

The quest for persistent radio emission associated with FRB and their link with nebulae

Author: Gabriele Bruni[1]

Co-author: Luigi Piro [2]

[1] *INAF - Istituto di Astrofisica e Planetologia Spaziali*

[2] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: gabriele.bruni@inaf.it

A detailed investigation of the environments in which bursts occur is one of the most promising approaches to shed light on these mysterious phenomena. Observations of a limited number of events suggest multiple progenitor channels, resulting in distinct locations, local environments, and host galaxy properties. The recent discovery of persistent radio sources associated with FRB 20201124A and FRB 20240114A supports the nebular model for the continuum emission, narrowing down the progenitor candidates to magnetars (favoured) or hyperaccreting X-ray binaries. In the near future, the advent of new dedicated radio facilities is expected to deliver dozens of arcsecond-level localized FRBs per year, significantly improving the statistics on host galaxies and continuum counterparts. This talk will review the current developments and future prospects for the characterization of persistent radio sources with the SKA.

Topics:

Transients & GW follow-up

57

SEMPER: a semi-empirical model for extragalactic radio emission, insights and predictions with the SKAO

Author: Marika Giulietti[1]

Co-authors: Andrea Lapi [2]; Giovanni Gandolfi [3]; Huub Rottgering [4]; Isabella Prandoni [1]; Laura Bisigello [5]; Lumen Boco [6]; Marcella Massardi [1]; Marco Bondi [1]; Matteo Bonato [1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

[2] *SISSA*

[3] *INAF-OAR*

[4] *Leiden Observatory, Leiden University*

[5] *Università di Padova*

[6] *University of Heidelberg*

Corresponding Author: m.giulietti@ira.inaf.it

Star-forming galaxies (SFGs) are the dominant population in the faint radio sky, corresponding to flux densities < 0.1 mJy. Understanding star formation processes across cosmic time requires a panchromatic approach. Semi-empirical models, relying on minimal assumptions and exploiting empirical relations between galaxy properties, are particularly powerful in this context, enabling us to take full advantage of recent progress in radio and optical/near-infrared (NIR) observations. We have developed the Semi-EMPirical model for Extragalactic Radio emission (SEMPER) to predict radio luminosity functions and number counts at 1.4 GHz and 150 MHz for SFGs. SEMPER combines redshift-dependent galaxy stellar mass functions derived from deep near-infrared (NIR) data with state-of-the-art empirical relations, such as the galaxy main sequence and the far-IR/radio correlation, with the goal of better understanding the radio properties of high-z, massive galaxy populations. The model has demonstrated excellent agreement with recent observations from the Very Large Array (VLA) and the Low-Frequency Array (LOFAR) at 1.4 GHz and 150 MHz, respectively. Notably, SEMPER naturally predicts the presence of a significant population of massive, dust-obscured

galaxies already in place at high redshifts, as also suggested by recent JWST observations. This talk will present our semi-empirical framework and its predictive capabilities in the context of upcoming surveys conducted with the Square Kilometre Array Observatory (SKAO). The exceptional sensitivity and broad redshift coverage of the SKAO Low and Mid arrays will open a unique window onto the evolution of the cosmic star formation rate density, providing an unprecedented opportunity to refine SEMPER's predictions.

Topics:

Galaxy Evolution & AGN

58

Multifrequency study of the Crab giant pulses

Author: Luca Beduzzi[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: lucabeduzzi@gmail.com

Giant pulses (GPs) are very energetic and impulsive phenomena associated with the Crab pulsar, with flux densities up to few MJy and pulse widths ranging from ~100 ns to ~100 μs. GPs observed from the Crab pulsar can be used to study the energy distribution and their dynamic spectra can address the emission mechanisms of neutron stars. In this talk I will present multifrequency observations of the Crab GPs at 408 MHz, 820 MHz and 1400 MHz, carried out with the Northern Cross, Green Bank and Noto telescopes. I will discuss how the GPs energy and arrival time distributions derived from our observations can constrain the physical mechanism responsible for their emission and discuss the connection with the fast radio bursts (FRBs) emission mechanisms. I will conclude my talk by outlining how the SKAO will be able to significantly push forward single pulsars' and population' GP studies and thus drive a better understanding of FRBs emission mechanisms.

Topics:

Pulsars & GW detection (PTAs)

59

Dipole analyses of cosmic radio background with SKA

Author: Tiziana Trombetti[1]

Co-author: Carlo Burigana [1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: tiziana.trombetti@inaf.it

The peculiar motion of the observer induces boosting effects in the anisotropy pattern of the background. The monopole frequency spectrum of the background is altered and transferred to higher multipoles, most prominently to the dipole, which retains the imprint of the isotropic background spectrum. Thanks to the high sensitivity and resolution of SKA, these patterns can be extracted even from limited sky regions, carefully selected to minimize foreground contamination. SKA will enable the study of various types of dipole signals, ranging from the integrated contribution of extragalactic sources to diffuse free-free emission, from the redshifted 21 cm line to low-frequency spectral distortions of the CMB. Comparing the dipole with the underlying monopole provides constraints

on the observer's velocity and, when combined with CMB analyses, helps disentangle the kinematic and intrinsic components of the cosmic dipole. Finally, the capabilities of the SKA Low and Mid (AA* and AA4) configurations are discussed, considering both short and long baselines, which are crucial for significantly reducing confusion noise.

Topics:

Cosmology

60

Measuring our peculiar velocity with SKAO

Authors: Bartolomeo Bottazzi Baldi[1]; Daniele Bertacca[2]; Mohamed Yousry Elkhashab[None]

[1] *Università degli Studi di Padova*

[2] *Dipartimento di Fisica e Astronomia "Galileo Galilei" Universita' degli Studi di Padova*

Corresponding Author: bartolomeobottazzibaldi@gmail.com

Our peculiar velocity imprints a dipolar signal on the large-scale clustering of galaxies. This effect leaves a distinctive oscillatory pattern on the power spectrum multipoles of galaxy clustering, which we refer to as FOTO effect (Finger Of The Observer). By performing a boosting technique on a galaxy catalog, we are able to use exploit this signature to constrain the magnitude and direction of our peculiar velocity from measurements of the large-scale power spectrum multipoles. Using mock galaxy catalogues created via the LIGER method, we measure the constraining power of the boosted SKAO1 and SKAO2 FOTO signals on our peculiar velocity. In particular, we showcase the improvement gained by using deeper and thicker redshift bins.

Topics:

Cosmology

61

Hunting for the 21 cm Forest in High-redshift Quasars with SKAO

Author: Chanasorn Kongprachaya[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: c.kongprachaya@gmail.com

The Epoch of Reionization (EoR) is one of the least understood periods in cosmic history. Observations from different probes, including quasar absorption spectra, the cosmic microwave background (CMB) polarization, Lyman-α emission from high redshift galaxies, suggest that the hydrogen neutral fraction in the intergalactic medium (IGM) was likely less than 5% at $z < 6$ and more than 70% at $z \sim 10$, with a mid-point of reionization occurring near $z \sim 7.5$.

A crucial probe of cosmic reionization is the redshifted 21 cm hydrogen hyperfine transition, as it directly probes the ionization state of the IGM, unlike most other observables. Most of the current interferometric observations aim to observe the signal as a contrast against CMB. For instance, the HERA Collaboration placed strict upper limits on the spatial and redshift evolution of the 21 cm power spectrum in the range $0.23 - 1.9\ h\,\mathrm{Mpc}^{-1}$ at $z = 7.9$ and $z = 10.4$. Over the last few years,

probing with the absorption against a bright radio source has attracted considerable attention due to the increasing number of discovered quasars at $z > 6$, a fraction of which are also radio-loud.

In this talk, I will present the first observation with the Giant Metrewave Radio Telescope (GMRT) of J352.4034-15.3373, which is a radio-loud quasar near the end of EoR, $z = 5.84$, covering the $200 - 225$ MHz frequency range. We achieved a 6 mJy rms noise per 390 kHz channel and no absorption detection, yielding a 95% upper limit on the 21 cm optical depth $\tau_{21} < 10^{-2}$. Assuming that the IGM was heated up to 500 K, this upper limit translates into 95% upper limits on the IGM neutral fraction $x_{\rm HI} < 0.3$ and 0.45 at $z = 5.25$ and 5.84, respectively. I will conclude my talk by outlining the role of SKAO in constraining reionization and the thermal properties of the IGM via observations of 21 cm absorption against high-redshift quasars.

Topics:

Epoch of Reionization and Cosmic Dawn

62

The LOFAR view of the Euclid Deep Field North

Author: Marco Bondi[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: m.bondi@ira.inaf.it

LOFAR has proved to be one on the most successful SKA pathfinder in the
Northern hemisphere opening up a poorly investigated radio window
providing observations at 144MHz with unprecedented sensitivity and resolution with the addition of the International Stations.
The Euclid Deep Field North (EDFN), located at RA=269.73 deg and
Dec=+66.02 deg in the North Ecliptic Pole (NEP) region, is the fourth
field of the LOFAR Deep Field project, and the only deep field in the
northern sky to be observed by the Euclid mission.
The Euclid satellite will cover the circular shape 20 sq deg of the
EDFN with multiple passes providing high-resolution near-IR imaging
(~0.3 arcsecond) down to the full depth of H=26 by DR3.
In this talk I will present an overview of the LOFAR observations on the EDFN, the status of the data processing and some of the results obtained so far imaging the EDFN with an angular resolution ranging from 6” down to 0”.3.

Topics:

Galaxy Evolution & AGN

63

HI properties of quiescent galaxies at <z>=0.4

Authors: Alessandro Bianchetti[1]; Francesco Sinigaglia[2]; Giulia Rodighiero[3]; Mattia Vaccari[4]

[1] *Istituto Nazionale di Astrofisica (INAF)*

[2] *Università degli Studi di Padova*

[3] *University of Padova*

[4] *University of the Western Cape*

Corresponding Author: alessandro.bianchetti@phd.unipd.it

HI studies have been longly limited to z<0.4 due to limited sensitivity of interferometric facilities, not deep enough to compensate for the intrinsic faintness of the 21-cm line. A computationally cost-effective alternative is stacking, which allows us to determine average HI properties of samples of galaxies beyond the detection limit. Pioneering works with MeerKAT, ASKAP, jVLA, and uGMRT have paved the way by tracking down HI properties for samples of star-forming galaxies, lying on the so-called Main Sequence, beyond the Local Universe. While Main Sequence galaxies have been a target for HI studies for several years already, quiescent galaxies have been largely neglected at z>0. Traditionally considered to contain little to no gas, HI content in quenched galaxies is a debated topic, with inhomogeneous and contradictory results across literature.
We propose a spectral stalking analysis of two separate, diverse samples of galaxies below the Main Sequence, selected with different criteria. We find evidence for a connection between HI and dust content, linking up with existing scenarios for gas rejuvenation. Moreover, we also find modest dependence of HI content on morphology and environment, building up on older results with diverse interpretations. Larger surveys with wider sky coverage may provide more statistically-robust samples, most suited to enhance our understanding of which parameters best drive HI content in quiescent galaxies. SKA-level sensitivities will put our view on HI properties forward in redshift.

Topics:

Galaxy Evolution & AGN

64

Using SKAO to understand the clustering of gravitational wave sources

Author: Michele Bosi[1]

[1] *University of Trento / SISSA*

Corresponding Author: mbosi@sissa.it

The SKAO's ability to survey the radio continuum and neutral hydrogen (HI) signals with a wide sky coverage and up to high redshift makes it a cardinal experiment to probe the large-scale structure of the Universe. Radio continuum galaxies and the HI signal from intensity mapping (IM) constitute cosmological tracers capable of enhancing the astrophysical and cosmological information embedded in other observables, in particular gravitational waves (GWs). Therefore, given the redshift overlap, it is valuable to explore the synergy among these SKAO datasets and GWs detected by upcoming third-generation interferometers.
In this work, we first determine which of the aforementioned SKAO tracers provides the best cross-correlation with GW data to investigate the astrophysical or primordial origin of the merging binary black holes. Secondly, we focus on statistically constraining the profile of the GW redshift distribution. This can be linked to the parameterization of the time delay probability and of the GW event probability as a function of the halo mass. Since the cross-correlation amplitude deeply relies on the redshift profile of the involved tracers, through such cross-correlation signal, we constrain those probability functions and, thus, the GW redshift distribution.

Topics:

Cosmology

65

Constraints on dark matter annihilation from the study of radio halos in galaxy clusters

Author: Paolo Marchegiani[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: paolo.marchegiani@inaf.it

Dark matter annihilation is a possible source of relativistic electrons in galaxy clusters; these electrons, when interacting with the cluster magnetic field, can produce a diffuse synchrotron emission with properties similar to those of radio halos.
In principle, if dark matter annihilation is the main source of electrons producing the radio halos, from the halos properties it would be possible to derive constraints on the properties of dark matter. However, in galaxy clusters other processes can provide relativistic electrons, and the dark matter originated electrons themselves can be reaccelerated on diffuse scale by processes related to the cluster turbulence, making it difficult to derive constraints on dark matter from observations of radio halos.
In this talk, we discuss how high frequency observations of radio halos can be useful to derive better constraints on the dark matter properties, at the light of recent observations of the halo in the Coma cluster with SRT, and of the expected properties of the SKAO in AA* and AA4 configurations for more distant clusters.

Topics:

Galaxy Clusters & LSS (relativistic particles and magnetic fields)

66

Radio properties of low-redshift Little Red Dot (LRD) candidates

Author: Gayathri Santhosh[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: gayathri.santhosh@inaf.it

Recent extragalactic surveys with the JWST have uncovered a population of compact, extremely red sources at high redshift called Little Red Dots (LRDs) which are characterised by V-shaped continuum with a vertex at around 4000 Å. Interestingly, studies have shown that their number density decreases towards lower redshifts (<4). Two competing ideas suggest that LRDs may be extremely dusty/obscured BL-AGNs or dusty SFGs. In this talk, I present preliminary results from a study of radio properties of Euclid selected LRD candidates in the three Euclid deep fields (North, South and Fornax), using MeerKAT and LOFAR radio data. The compactness of Euclid-selected LRDs has not been confirmed by JWST. So these sources should be regarded as LRD candidates. Studies in the radio can help determine their true nature and stacking analysis can be used to derive upper limits to their radio luminosities. Finally, I will highlight how SKA, with its unprecedented sensitivity, resolution and wide frequency coverage, is a transformative instrument to study LRDs by enabling the detection of faint radio emissions, thus providing more insight about the physical nature and the temporal evolution of this enigmatic population.

Topics:

Galaxy Evolution & AGN

67

AGN feeding and feedback revealed in detail by MeerKAT and the SKA

Author: Filippo Maccagni[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: filippo.maccagni@inaf.it

Active Galactic Nuclei (AGN) are key drivers of galaxy evolution, triggered by cold gas accreting onto a super-massive black hole. However, the processes regulating this gas accretion (feeding) and how AGN alter the interstellar medium to affect star formation (feedback) remain poorly understood. A major observational challenge is the vast range of spatial scales involved: AGN fuelling and jet-ejection occur over the sub-pc scales, while AGN feedback shocks and heats the ISM preventing star formation over the galactic and circum-galactic scales. Moreover, it is unclear how short stochastic AGN episodes are connected with the long timescales of gas accretion and star formation.

In this talk, I will highlight how MeerKAT observations allow us to overcome these observational limitations with two examples. In NGC 3100, a 300 kpc-long, low-density ($\sim 10^{19}$ cm^{-2}) HI filament fuels a cold gas circum-nuclear disk, where HI clouds fall onto the SMBH. Meanwhile, broad-band continuum observations of Fornax A reveal the rapid flickering of its AGN. Additionally, multi-wavelength observations MeerKAT, ALMA, MUSE show a jet-driven multi-phase gas outflow alongside clouds fuelling the AGN, explaining its rapid recurrent activity.

Finally, I will show how the SKA will open a new parameter space in AGN studies. I will present simulated SKA AA*/AA4 broad-band continuum and HI observations of a nearby AGN, comparing them with the Fornax A MeerKAT observations. Together, the SKA-LOW and MID telescopes will enable detailed observations of AGN feeding and feedback in hundreds of nearby AGN down to low radio powers (10^{23} W Hz^{-1}).

Topics:

Galaxy Evolution & AGN

68

The great synergy between SKA and THESEUS

Author: Lorenzo Amati[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: lorenzo.amati@inaf.it

The Transient High-Energy Sky and Early Universe Surveyor (THESEUS) is a space mission concept under study by ESA as candidate M7 mission, aiming at exploiting Gamma-Ray Bursts for investigating the early Universe and at providing a substantial advancement of multi-messenger and time-domain astrophysics. THESEUS will address main open issues in cosmology such as, e.g., star formation rate and metallicity evolution up to redshift >10, Pop III stars, cosmic re-ionization. In addition, it will provide a fundamental contribution to time-domain and multi-messenger astrophysics by identifying the electromagnetic counterparts to sources of gravitational radiation, which will be routinely detected in the late '30s and the '40s by next generation facilities like Einstein Telescope and studying most classes of transient sources, thus providing an ideal sinergy also with the large observatories of the near future like LSST, ELT, TMT, SKA, CTA, ATHENA. In particular, the perspective sinergy between THESEUS and SKA is apparent. First of all, the two observing facilities will address fundamental open issues in cosmology through complementary measurements and methods, whose combination will allow to increase substantially the accuracy and reliability in the

determination of, e.g., star formation rate evolution up to the very early Universe, physics and evolution of cosmic re-ionization, detection and characterization
of pop III stars and first galaxies. In addition, THESEUS will be a wonderful machine for the detection, characterization and redhsift measurement of any kind of GRBs and many classes of X-ray transients. The combination of THESEUS data with those from simultaneous and follow-up observations of these phenomena with SKA will provide unique clues to their physics, progenitors and, more in general, will be a cornerstone contribution to the time domain and multi-messenger astrophysics of the future.

Topics:

Transients & GW follow-up

69

Epoch of Reionization observations with SKAO: lessons learnt from LOFAR and synergies with MeerKAT

Author: Emilio Ceccotti[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: e.ceccotti@ira.inaf.it

Observations of the redshifted 21-cm signal from neutral hydrogen during the Epoch of Reionization and Cosmic Dawn are crucial for understanding the physics of the early Universe and one of the SKAO main science goals. Detecting this signal, however, remains challenging due to the presence of bright astrophysical foregrounds and instrumental systematics. Current low-frequency SKAO pathfinders are playing a key role in developing the data analysis techniques needed for the upcoming SKA-Low observations. In this talk, I will present recent progress with LOFAR – an SKAO pathfinder –, including advanced techniques for modelling and subtracting bright foreground sources, as well as the latest power spectrum results, which currently provide the most stringent upper limits at z~9. I will discuss how these lessons will inform early SKAO observations and I will also introduce how the cross-correlation between the 21-cm signal and other probes can aid a detection, focusing particularly on the cross correlation with MeerKAT CO intensity mapping observations.

Topics:

Epoch of Reionization and Cosmic Dawn

70

Connecting Fast Radio Bursts to their progenitors: demographic surveys and associated persisting radio sources with SKA

Author: Davide Pelliciari[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: davide.pelliciari@inaf.it

Fast Radio Bursts (FRBs) are bright (Jy-level) radio flashes from extragalactic distances, with still uncertain origins. While magnetars are often proposed as progenitors, this scenario struggles to explain some key observables, such as the high observed rate of some active repeaters. The Square

Kilometre Array (SKA), with its high sensitivity, wide field of view, and precise resolution, will push forward FRB science. FRB observations will be commensal to any other survey, allowing, for example, to expand their demographic studies, i.e. the link between their properties and the host galaxies, particularly extending them at higher redshifts. As part of this commensality, the sample of persistent radio sources associated with FRBs will increase by more than one order of magnitude, enabling a further test of the FRB-progenitor connection. In this talk I will present a study on the FRB-progenitor connection carried out with two different suveys: an FRB search in nearby star forming galaxies carried out with the Northern Cross at 408 MHz and a 1.4 GHz search for persistent radio sources associated with FRBs carried out with the uGMRT. I will conclude by showing the perspective to improve these surveys with the SKA.

Topics:

Transients & GW follow-up

71

Hydrogen intensity mapping with MeerKAT: ongoing efforts

Author: Isabella Paola Carucci[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: isabella.carucci@inaf.it

Radio telescopes tomographically characterise the Universe thanks to detecting the redshifted 21 cm radiation emitted by cosmic neutral hydrogen, HI. One of the most significant challenges for performing this measurement is removing the contaminants, i.e., orders of magnitude more intense foregrounds coupled with not-yet-characterised instrumental systematics. In this talk, I will discuss how we address this challenge with first-of-their-kind data from the MeerKAT single-dish observations. Within the MeerKLASS collaboration, we started an effort to test and optimise the available contaminant cleaning methods directly on data. We assess their effectiveness by measuring the expected cross-correlation signal with an overlapping galaxy dataset. I'll present our results, which are encouraging and relevant for the forthcoming direct detection of the IM signal with MeerKAT. Our ongoing work demonstrates that a radio array operating as a collection of independent telescopes can probe the IM cosmological signal, marking a milestone for the cosmology science case with the entire SKAO (which the MeerKAT dishes will be part of).

Topics:

Cosmology

72

Searching for revived fossil plasma sources in galaxy clusters

Author: Luca Bruno[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: l.bruno@ira.inaf.it

LOFAR surveys have enabled unprecedentedly detailed analysis of large-scale, diffuse, and steep-spectrum sources in galaxy clusters, such as radio relics and halos. These are thought to arise from particle re-acceleration operated in the intra-cluster medium (ICM) by shocks and turbulence triggered by a cluster merger. Similar processes are likely also responsible for the re-ignition of fossil

electrons from radio galaxies, thus forming amorphous and filamentary revived fossil sources . These are interesting targets to investigate the interplay between thermal and non-thermal components of the ICM, the injection of seed cosmic rays, the merging history of the host cluster, and the physics of radio filaments. Due to their ultra-steep synchrotron spectrum, a proper analysis of revived fossils requires sensitive and high-resolution multi-wavelength data at low radio frequencies. I will present the analysis of a sample of 7 candidate revived fossils, which have been selected by visual inspection of a sample of low-mass and nearby galaxy clusters in LoTSS-DR2 at 144 MHz, and then followed-up with the uGMRT at 400 MHz. I will show radio images, optical/X-ray overlays, and spatially-resolved spectral index maps that we used to interprete the nature of our targets. Our sample highlights challenges and opportunities in the selection and study of these sources in the SKA era.

Topics:

Galaxy Clusters & LSS (relativistic particles and magnetic fields)

73

Coherent and Incoherent Emission from the Ordered Magnetospheres of Low-Mass Stars, UCDs, and Massive Star

Author: Francesco Cavallaro[1]

Co-authors: Adriano Ingallinera [1]; Alessio Traficante [1]; Barnali Das [2]; Carla Simona Buemi [1]; Corrado Trigilio [1]; Cristobal Bordiu [1]; Filomena Bufano [1]; Giovanni Sabatini [3]; Grazia Maria Gloria Umana [1]; Joe Callingham [4]; Laura Driessen [5]; Matt Shultz ; Paolo Leto [1]; Sara Loru [1]; Stanley Owocki

[1] *Istituto Nazionale di Astrofisica (INAF)*

[2] *CSIRO*

[3] *INAF - Osservatorio Astrofisico di Arcetri*

[4] *University of Leiden*

[5] *University of Sydney*

Corresponding Author: francesco.cavallaro@inaf.it

The ordered magnetospheres of chemically peculiar (CP) massive stars and ultracool dwarfs (UCDs) provide ideal environments for non-thermal particle acceleration. In CP stars, radiatively driven winds are trapped into rigidly rotating magnetospheres until centrifugal breakout (CBO) occurs, when centrifugal forces overwhelm magnetic tension. These breakout events trigger reconnection and inject energetic electrons that radiate broadband incoherent emission via the gyro-synchrotron mechanism. Recent observations have demonstrated that the radio luminosity of CP stars scales with the available CBO power, establishing a robust link between magnetospheric dynamics and radio output.
Intriguingly, the few UCDs detected in quiescent radio emission also follow the same $L_{\rm rad} \propto L_{\rm CBO}$ relation, despite lacking the strong stellar winds that feed CP star magnetospheres. This raises a fundamental question: how do UCDs maintain a reservoir of ionized matter capable of sustaining CBO-driven processes?
The Square Kilometre Array (SKA), with its sensitivity and wide spectral reach, will provide the first opportunity to test the CBO paradigm in UCDs, constrain their plasma sources, and extend scaling laws of magnetospheric radio emission from massive stars down to the substellar regime.

Topics:

Cradle of Life & Our Galaxy

74

The soft X-ray transient EP241021A: a cosmic explosion with a complex structure from a massive progenitor

Author: Giulia Gianfagna[1]

Co-authors: Luigi Piro [2]; Gabriele Bruni [3]; Aishwarya Linesh Thakur [2]; Hendrik van Eerten [4]

[1] *Istituto Nazionale di Astrofisica (INAF), Istituto di Astrofisica e Planetologia Spaziali (IAPS)*

[2] *Istituto Nazionale di Astrofisica (INAF)*

[3] *INAF - Istituto di Astrofisica e Planetologia Spaziali*

[4] *University of Bath*

Corresponding Author: giulia.gianfagna@inaf.it

EP241021a belongs to the class of X-Ray Flashes (XRFs), fast X-ray transients discovered by the BeppoSAX satellite. Diverse evidence indicates that XRFs are connected to Gamma Ray Bursts (GRBs) and likely represent their softer analogues. Several models have been proposed to explain the observed properties of XRFs, mostly in the context of collapsar scenario, like off-axis GRBs and baryon-loaded explosions (cocoons). Here we present the results of our extensive campaign in radio (uGMRT, ATCA, e-MERLIN, ALMA), but also in optical and in X-rays, of the afterglow of EP241021a. The afterglow is characterized by multiple components, which represent the imprints of the interaction of a jet with the complex environment of the pre-existing progenitor, that is likely shaping its structure. Moreover, the radio emission clearly shows the presence of a structured cocoon, with a mildly relativistic and a non-relativistic component. The radio spectral coverage from 1 to ~200 GHz was fundamental to constrain the structure of this soft X-ray transient, that, after all, revealed to be not so different from a Gamma Ray Burst indeed.

Topics:

Transients & GW follow-up

75

The MeerKAT HI View of NGC 1365, the Great Barred Spiral Galaxy

Author: Viviana Casasola[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: viviana.casasola@inaf.it

The interstellar medium (ISM) regulates star formation, a key driver of galaxy evolution. Understanding how atomic and molecular gas, dust, and metals interact is crucial for deciphering these processes.

I present high-resolution MeerKAT HI observations of NGC 1365, the Great Barred Spiral Galaxy in the Fornax cluster, and compare them with ALMA molecular gas, DustPedia dust, and gas-phase metallicity data. The analysis reveals new insights into the interplay between ISM components and suggests that HI may play a more significant role in regulating star formation than previously recognized.

These observations demonstrate the power of high-sensitivity, high-resolution HI studies, providing a critical benchmark for SKA surveys and advancing our understanding of the cosmic evolution of galactic gas.

Topics:

Galaxy Evolution & AGN

76

Gaseous flows as probe of galaxy evolution: the SKA revolution

Author: Ilaria Ruffa[1]

[1] *INAF-Arcetri*

Corresponding Author: ilaria.ruffa@inaf.it

Gas accretion and depletion processes are key drivers of galaxy evolution. Cold gas may indeed be accreted from the CGM/IGM or recycled internally, becoming the fuel for the formation of new stars. If funnelled sufficiently inward, it can also feed the central super-massive black holes (SMBHs), giving rise to an active galactic nucleus (AGN). Both young stars and the AGN can then release large amounts of energy (i.e. feedback) onto their surroundings, altering the cold ISM physics or even expelling it from the host galaxy, thus dramatically affecting its fate. Mapping the distribution and kinematics of cold gas, from the outskirts to the innermost regions of galaxies, is thus vital to unveil how these processes affect galaxy evolution.

Studies of neutral atomic hydrogen (HI) are crucial in this context. HI traces the bulk of the cold gas reservoirs in the outer regions of galaxies and in their CGM, while absorption studies reveal its presence even close to central SMBHs, tightly linked to the molecular gas phase. It can thus provide direct evidence of galaxy-galaxy interactions or gas stripping phenomena when extended, dark HI filaments/clouds are observed connecting companion galaxies or within the IGM. However, such structures often exhibit very low column densities ($N_{\rm HI}$ $lesssim 10^{19}$ cm^{-2}), requiring ultra-sensitive observations to be detected.

The advent of the SKA precursor MeerKAT has started to revolutionise this type of studies, enabling - for the first time - mapping of diffuse HI gas down to column densities of $\sim 10^{18}$ cm^{-2} with $\sim 10''$ resolution out to $\sim$ 20 Mpc, within only a few tens of observing hours. In this talk, I will present recent results that exploit exquisite MeerKAT's sensitivity to investigate HI flows across multiple environments. I will then focus on the 25h MeerKAT observations of the nearby NGC3557 galaxy group, showing how these very deep (i.e. $N_{\rm HI} \approx 8 \times 10^{18}$ cm^{-2} at $10''$) data allow us to revolutionize our understanding of the > 20 objects within the field of view. I will also illustrate how the combination of MeerKAT (SKA, in the future) and ALMA observations at comparable resolution is crucial to build a complete picture of the cold ISM (both atomic and molecular) across all spatial scales, from galaxy outskirts to the vicinity of SMBHs. These studies mark a turning point, demonstrating how next-generation radio facilities will fundamentally reshape our view of galaxy evolution.

Topics:

Galaxy Evolution & AGN

77

The impact of radio-faint AGN on the Star formation rate–Radio Luminosity Relation: lessons from VLBA and prospects with SKA

Author: Giorgia Peluso[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: giorgia.peluso@inaf.it

The Square Kilometre Array (SKA) will open a new observational window on the radio-faint sky. The large sky coverage and the high sensitivity of this facility will enable us to reconstruct, for the first time, the distribution of the sub-μJy radio sources. The milliarcsecond-scale spatial resolution delivered by the SKA-VLBI project (SKA - phase2) will also allow to detect compact radio cores at brightness temperatures of $T_b > 10^5 K$. This measurement will serve as a reliable AGN diagnostic in the sub-μJy range.

The contribution of faint, previously hidden sub-μJy AGN has been suggested as a major source of contamination in key star-formation–regulated relations, such as the star formation rate (SFR)–radio luminosity relation. For instance, the Infrared - Radio Correlation (IRRC), which arises from the relationship between radio luminosity and obscured SFR (e.g., SFR measured in the infrared), is well-known to flatten at high ($\approx 10^{10} M_\odot$) stellar masses. Contamination to the total radio luminosity from AGN jets buried in the highly star forming galactic nuclei was hypothesized to explain this flattening. Understanding the role of such contaminants is crucial, as uncertainties in these relations bias our interpretation of star-forming processes and, ultimately, our understanding of galaxy growth and evolution.

Recent pioneering VLBA surveys have already attempted to address this challenge, though these studies were limited by the narrow field of view and the relatively lower sensitivity of the VLBA with respect to SKA. The AGN-sCAN survey, for instance, targeted 500 galaxies at 1.4GHz in the COSMOS field, reaching a sensitivity limit of 25 μJy/beam. These galaxies were selected to lie around the IRRC, therefore classified as pure star forming galaxies by previous low-resolution ($\sim$ arcsec scale) VLA observations. Their high stellar masses (>$10^{10} M_\odot$) made them promising candidate to host hidden AGNs. Thanks to the high-spatial resolution (~ mas scale) of the AGN-sCAN - VLBA observations, we were able to disentangle the emission from AGN and stars in the galactic nuclei, and identify the faintest AGN ever detected in massive star-forming galaxies. In the deepest regions we detect 4 VLBA sources, which translates into an effective AGN detection rate of 9%, in good agreement with the predicted AGN number counts at these flux densities. Interestingly, we find that the IRRC is completely unaffected by this correction, even though the AGN flux contamination (~30%) in our individual VLBA detections is non-negligible. However, we could not rule out the incidence of radio-silent AGN at sub-μJy levels, below the VLBA sensitivity limit.

The next decisive step will come with SKA. Crucially, SKA will make it possible to extend this analysis into the sub-μJy regime and over much larger areas of sky. This will allow us to rigorously test predictions of AGN number counts in this faint regime and definitively assess the contribution of non radio-excess AGN on the observed relations between star formation and radio emission.

Topics:

Galaxy Evolution & AGN

78

AGN or star formation? The role of wide-field VLBI surveys and the path to the SKA

Author: Ivan Delvecchio[1]

[1] *INAF-OAS*

Corresponding Author: ivan.delvecchio87@gmail.com

Understanding the interplay between active galactic nuclei (AGN) and star-formation activity in galaxies stems from our ability to disentangle and gauge the emission arising from both phenomena. I will present the preliminary results obtained from "AGN-sCAN", a high-resolution (0.01 arcsec) radio survey carried our with the Very Long Baseline Array (VLBA) in the COSMOS field. The combination between these VLBA and lower-resolution (arcsec) radio imaging enable us to: (i) pinpoint

radio-quiet AGN misclassified as “normal” star-forming galaxies; (ii) calibrate AGN-free radio vs star formation rate conversions; (iii) identify peculiar (wandering, dual and binary) AGN candidates owing to superb angular resolution and astrometry. I will also discuss current limitations of wide-field VLBI surveys and how the next SKA(+VLBI), in tandem with multi-wavelength facilites, will bring us closer to a complete census of AGN and star-forming galaxies.

Topics:

Galaxy Evolution & AGN

79

Exploring radio processes at cosmic noon with WISSH

Author: Matteo Fanelli[1]

Co-authors: Enrico Piconcelli [1]; Francesca Panessa [1]; Gabriele Bruni [2]

[1] *Istituto Nazionale di Astrofisica (INAF)*

[2] *INAF - Istituto di Astrofisica e Planetologia Spaziali*

Corresponding Author: matteo.fanelli@uniroma1.it

Hyper-luminous QSOs (HyLQSOs, i.e. $L_{bol} > 10^{47}$ erg/s), are powered by the most massive, highly-accreting supermassive black holes (SMBHs, i.e. $M_{BH} > 10^{9}\ M_{\odot}$). Following the nowadays consensus view on SMBH-host galaxy co-evolution, the huge amount of energy released by highly-accreting SMBHs in HyLQSOs is able to strongly affect the evolution of the host galaxy by heating and expelling the interstellar medium (ISM) (the so-called “AGN feedback” mechanism). The radio band can provide us with fundamental information on the presence of jets, their interplay with winds, and in general on the presence of a possible young radio phase at cosmic noon, and the long-standing questions about the radio-loud/radio-quiet dichotomy across cosmic epochs.
To this purpose, between 2022 and 2025, we realized a radio multiwavelenght survey of the WISSH sample with the uGMRT and JVLA. This, along with the LoTSS archival data, allowed us to cover a wide range of frequencies, spanning from 0.15 to 12 GHz. In particular, we managed to reach a sensitivity threshold of $\sim$30 μJy, an order of magnitude below past or current radio surveys. This allowed us to reveal faint radio emission from the cosmic noon quasars, reaching a detection rate of $\sim$74\% at 3 GHz. This will enable us to extend the study of the radio-optical and radio-X-ray correlations at their brightest end.
These sources represent an optimal testing ground for SKAO. While SKAO alone will cover the whole frequency range of our survey, its sensitivity will allow us to go deeper by an order of magnitude, giving us the opportunity to explore even more the radio properties of this class of faint quasars.
In this talk I will give an overview of the results obtained with our survey and explore the new possibilities with the income of the SKAO.

Topics:

Galaxy Evolution & AGN

80

SPRITZ+HI: pouring neutral hydrogen into the simulated sky cocktail

Author: Laura Bisigello[1]

[1] *INAF-OAPD*

Corresponding Author: laura.bisigello@inaf.it

In this talk I'll present the most recent update of the state-of-the-art phenomenological simulation SPRITZ to include neutral hydrogen (HI). This update has been performed using the empirical stellar mass - HI mass relation and validate against available observations. SPRITZ already correctly reproduce the stellar mass function at different redshifts and the molecular gas mass density and with the inclusion of the HI it can be now be used to fully investigate the baryon content of the Universe and perform predictions for SKA.

Topics:

Galaxy Evolution & AGN

81

One telescope to find them all: a MeerKAT hunt for radio rings

Author: Cristobal Bordiu[1]

Co-authors: Filomena Bufano [1]; Grazia Maria Gloria Umana [1]; Ricardo Rizzo ; Cristiana Spingola ; Corrado Trigilio [1]; Sara Loru [1]; Miroslav Filipovic ; Carla Simona Buemi [1]; Francesco Cavallaro [1]; Luciano Cerrigone ; Paolo Leto [1]; Adriano Ingallinera [1]; Simone Riggi [2]; Alan Cosimo Ruggeri [1]; Zachary Smeaton ; Patrick Wouldt

[1] *Istituto Nazionale di Astrofisica (INAF)*

[2] *INAF - Osservatorio Astrofisico di Catania*

Corresponding Author: cristobal.bordiu@inaf.it

Circumstellar shells are a key manifestation of the mass-loss processes of evolved stars in the radio band. These faint and compact ring-like structures—from planetary nebulae around low- and intermediate-mass stars to the ejecta surrounding the more massive Luminous Blue Variables and Wolf-Rayets—are the result of the interplay between stellar winds and eruptions and the surrounding ISM. Therefore, the detection and analysis of these shells is crucial to understanding stellar evolution and feedback at Galactic scales. Until now, however, systematic, large-scale searches for ring-like structures in the radio have been hampered by the limited resolution and sensitivity of past continuum surveys.

In this context, the advent of SKA precursors has opened a new window for discovery, rapidly overcoming these limitations. Instruments such as ASKAP and MeerKAT now survey vast areas of the sky with unprecedented sensitivities (tens of μJy beam^{-1}) and angular resolutions approaching those of optical and infrared surveys. These enhanced imaging capabilities are paving the way for a new era in the study of evolved stars at radio wavelengths, enabling both more accurate characterisation of known objects and the discovery of previously undetected populations.

This talk will review recent discoveries of circumstellar ring-like structures made with SKA precursors, with a focus on the outcomes of a dedicated search for low-angular diameter radio rings using MeerKAT data from the SARAO MeerKAT Galactic Plane Survey and the Galactic Centre mosaic. This work has unveiled over 160 new radio rings of uncertain nature. This unexplored sample holds strong potential for the discovery of large number of evolved star candidates. I will describe the sample's general properties and the results of an initial multiwavelength assessment, which has allowed to identify a subset of the rings as potential mass-loss relics around new Luminous Blue Variable candidates. Finally, I will discuss detection prospects as SKA precursor capabilities continue to expand, and how this work and future follow-ups will contribute to a more complete census of evolved stars in the Milky Way.

Topics:

Cradle of Life & Our Galaxy

82

Multi-tracer forward-modeling of the first billion years

Author: Andrei Mesinger[1]

[1] *University of Catania*

Corresponding Author: andrei.mesinger@gmail.com

The 21cm signal promises to revolutionize our understanding of the first cosmic structures, eventually allowing us to map out the entire observable Universe. However, we have yet to obtain a detection of the interferometric radio signal from this Cosmic Dawn of structure. In these early days, it will be of utmost importance to synergize preliminary 21cm observations with more established probes in order to learn complimentary physics as well as confirm initial claims of a detection. I will introduce 21cmFASTv4, a new version of the public simulation package for interpreting multi-tracer observations of the first billion years. 21cmFASTv4 features a new, efficient halo finder as well as a flexible semi-empirical framework to connect galaxies to host halos. Built with field-level Bayesian inference in mind, it allows for self-consistent forward models of multiple tracer fields (e.g. 21cm, galaxies, CMB anisotropies, line intensity maps), as well as the inclusion of residual systematics during post-processing. I show some examples of this approach, including interpreting recent results from the HERA telescope, high-z galaxy observations from JWST, as well as field-level inference from galaxy and 21cm maps.

Topics:

Epoch of Reionization and Cosmic Dawn

83

Advancing Polarization Calibration in LOFAR Beamformed Data: A Stepping Stone to SKA Low

Author: Caterina Tiburzi[1]

Co-authors: Maaijke Mevius [2]; Willem van Straten [3]

[1] *Istituto Nazionale di Astrofisica (INAF)*

[2] *ASTRON*

[3] *Manly Astrophysics*

Corresponding Author: caterina.tiburzi@inaf.it

The LOFAR interferometer, operating across 10–240 MHz, is among the most advanced precursors to SKA Low, paving the way for next-generation low-frequency radio astronomy. LOFAR's beamformed mode enables diverse science cases – such as pulsars, Solar and transient studies. However, polarization analysis in beamformed mode has remained largely out of reach due to the absence of a reliable polarization calibration framework.

In this talk, I will present our cutting-edge polarization calibration scheme tailored specifically for LOFAR's beamformed mode. This work faces a number of calibration challenges, and indicates the pitfalls of the currently-used beam model, but also serves as a stepping stone towards the robust polarization calibration needed to unlock the revolutionary capabilities of SKA Low.

Topics:

Pulsars & GW detection

84

The SKA view on supernova remnants

Author: Sara Loru[1]

Co-authors: Grazia Umana ; Corrado Trigilio ; Adriano Ingallinera ; Filomena Bufano ; Francesco Cavallaro ; Cristobal Bordiu ; Carla Buemi ; Paolo Leto ; Alan Ruggeri ; Simone Riggi ; Fabrizio Bocchino ; Elise Egron ; Alberto Pellizzoni ; Marco Miceli ; Giovanni Morlino ; Salvatore Orlando ; Alessio Traficante ; Oleh Petruk ; Luciano Cerrigone

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: sara.loru@inaf.it

The strong shocks involved in supernova remnants (SNRs) and their interaction with an often anisotropic surrounding medium make them very complex objects and ideal laboratories to study the production and acceleration of Galactic cosmic rays (CRs).
Despite being among the first object classes studied in radio astronomy, several observational challenges have so far prevented a full characterization of these extended sources, many aspects of which remain poorly understood. In particular, the contribution of SNRs to the population of Galactic CRs is still debated, as is the role played by their interaction with the surrounding environment in shaping the energy distribution of accelerated particles.
Moreover, local spectral variations are often observed within remnants, tracing regions under different physical conditions—affected by shock properties, variations in the surrounding medium, possible interactions with atomic or molecular clouds, the presence of pulsar wind nebulae (PWNe), and/or unrelated superimposed or embedded sources (typically HII regions). To properly identify and investigate these regions, high-resolution images at different frequencies and sensitive spectral index maps are essential.
In this context, SKA precursors—ASKAP, MeerKAT, and MWA—are providing valuable and often unexpected insights on SNRs, thanks to their unique ability to probe spatial scales from a few arcseconds to several degrees with sensitivities down to tens of microjansky. These capabilities have enabled the discovery of hundreds of new Galactic SNRs and the redefinition of the exact morphology of many known SNRs. Furthermore, accurate integrated flux density measurements and arcsecond-scale spectral index maps are now available for dozens of remnants, expanding well beyond the small group of classical SNRs traditionally studied in detail (e.g., Cas A, Tycho, Kepler).
Looking ahead, SKA-LOW and MID will further enhance these capabilities, providing improved sensitivity, resolution, frequency coverage, and image fidelity. This will allow detailed studies of CR acceleration, spectral breaks, and magnetic field structures.
This talk will offer a detailed overview of the most recent progress in SNR studies enabled by the SKA precursors and discuss future advancements expected with the upcoming SKA Observatory (SKAO), with particular focus on the key science cases being developed by the italian community on the study of SNRs.

Topics:

Cradle of Life & Our Galaxy

85

Advancing the Understanding of Neutral Hydrogen in the Post-Reionization Universe with the Upgraded GAEA Model

Author: Mohammad Kamran[1]

Co-authors: Fabio Fontanot [1]; Gabriella De Lucia [1]; Marta Spinelli [2]

[1] *Istituto Nazionale di Astrofisica (INAF)-Trieste*

[2] *Observatoire de la Côte d'Azur, France*

Corresponding Author: mohammadkamran.mohammadkamran@inaf.it

We investigate the distribution and evolution of atomic hydrogen (HI) in the post-reionization Universe ($z < 6$) using the latest, upgraded version of the GAlaxy Evolution and Assembly (GAEA) semi-analytical model, coupled with large-volume, high-resolution N-body simulations. This enhanced framework incorporates updated astrophysical processes that improve the realism of galaxy formation and gas evolution compared to earlier implementations.

We analyze the HI mass function, the cosmic HI density, and their evolution across cosmic time, as well as their dependence on host halo mass and assembly history. Our results highlight the crucial role of galaxy formation pathways in driving the scatter of the HI–halo relation. Importantly, we find that predictions from the new GAEA model show very good agreement with recent observational measurements of HI properties, strengthening its reliability as a tool for interpreting upcoming surveys.

We further present new fitting prescriptions aimed at constructing accurate mock HI maps for halo occupation distribution studies. The clustering of neutral hydrogen is also explored, with predictions for the HI bias, shot-noise contribution, and the redshift-space 21 cm signal, all of which are directly relevant for upcoming intensity mapping surveys. In particular, we assess the role of different galaxy populations—including HI-deficient satellites—in shaping the power spectrum on one-halo scales. Our findings provide updated, physically motivated predictions that can be directly tested with current and future radio facilities such as the Square Kilometre Array.

Topics:

Cosmology

86

Cosmic Rulers: Masers as Tools for Studying Galactic Structure from AU to kpc

Author: Kazi Rygl[1]

Co-authors: Alberto Sanna [1]; Andreas Brunthaler [2]; Anna Bartkiewicz [3]; Arshia Jacob [4]; Dieter Engels [5]; Jacco van Loon [6]; Lucero Uscanga [7]; Olga Bayandina [8]; Sandra Etoka [9]; Simon Ellingsen [10]; Tomoya Hirota [11]

[1] *Istituto Nazionale di Astrofisica (INAF)*

[2] *MPIfR*

[3] *Nicolaus Copernicus University in Torun*

[4] *University of Cologne*

[5] *University of Hamburg*

[6] *Keele University*

[7] *University of Guanajuato*

[8] *SKAO*

[9] *University of Manchester*

[10] *ICRAR*

[11] *NAOJ*

Corresponding Author: kazi.rygl@inaf.it

Maser emission is an multi-purpose tool of astrophysical research, offering a unique window into a vast range of astronomical sources and spatial scales - from a few astronomical units around forming protostars to kiloparsecs in distant galaxies. These naturally occurring microwave amplifiers penetrate the dust shells of star-forming regions, unveiling the intricate dynamics of accretion disks and outflows. On larger scales, they can trace the structure of a galaxy, reveal black hole surroundings, and illuminate galactic evolution. Masers not only map their host sites but also provide crucial information on system kinematics, polarization properties, and magnetic fields.

The SKA-Mid will enable observations of three most common masing molecules: hydroxyl and methanol masers during the first phase of commissioning, and later also water masers. The SKA's broad frequency range will also be crucial for discovering and studying new, yet unknown maser types. Masers, known for their extreme brightness, will play a key role in the early testing of the SKA, providing reliable reference sources for calibration. At the same time, faint masers, allowing detailed imaging and kinematical studies of their host environments, will be equally, if not more, valuable. The SKA's exceptional sensitivity will grant access to a complete view of nearby sources and extend our reach to far away objects, deepening our understanding of their physical conditions and potentially leading to groundbreaking discoveries.

With its extraordinary spectral resolution, the SKA will allow us to explore maser systems in unprecedented detail, from stellar nurseries and evolved stars to distant galaxies previously beyond our reach. Masers will be essential diagnostic tools for studying magnetic fields through their polarization properties, revealing the forces shaping the cosmos. Furthermore, multi-frequency, simultaneous observations will offer crucial insights into maser themselves, helping to decipher their formation and role in astrophysical processes. Masers are the ultimate all-purpose tools of astronomy - indispensable for any observatory under construction. With the SKA, we will refine our understanding of stellar evolution and galactic structure while uncovering new and unexpected discoveries, making masers a fundamental component of next-generation astrophysical research.

Topics:

Cradle of Life & Our Galaxy

87

Study of polarized emission in radio halos and filaments in the SKA era

Author: Valentina Vacca[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: valentina.vacca@inaf.it

Synchrotron diffuse emission at the centre of merging galaxy clusters and along filaments connecting them demonstrates the presence of relativistic particles and magnetic fields in these environments. Their properties represent a unique tool to constrain large-scale magnetic fields and the physics of the acceleration and transport of the relativistic particles. However, radio observations of these sources in total intensity are heavily limited by confusion of background radio sources (confusion noise). Polarization observations are less affected by confusion noise, due to the lower density of polarized sources with respect to total intensity. Nevertheless, despite technological progress, the detection of the polarization signal is still challenging due to its weakness. Recently, for the first time, we detected at the centre of a galaxy cluster a large-scale diffuse polarized emission extending up to scales of about 2.5 Mpc, i.e. up to the periphery of the cluster, where the total intensity is not detected likely due to observational limitations. This detection is particularly important because the polarized emission of these sources allows us to put constraints on the strength and the structure of the magnetic field relatively independently on the relativistic electron population.

In order to assess the capabilities of the SKA telescopes to observe these sources, we use cosmological magneto-hydrodynamical simulations to predict the expected full Stokes surface brightness of diffuse synchrotron sources at the centre of galaxy clusters and in filaments connecting them in the frequency band 950–1760 MHz. We explore the possibility to detect these sources with short observations (~15 minutes, as for the SKA-MID polarization survey planned by the SKA Magnetism Science Working Group) and with longer pointed observations. These simulations show that pointed observations are required in order to reveal these sources. Thanks to the unprecedented combination of sensitivity and spatial resolution, these observations will permit us to constraint the magnetic field properties and to understand if the energy density of relativistic electrons is in equipartition with the magnetic field or rather coupled with the thermal gas density. This will add a precious piece of information to our understanding of cosmological magnetic fields history.

Topics:

Galaxy Clusters & LSS (relativistic particles and magnetic fields)

88

Ensuring SKA Science: Spectrum Management Challenges

Author: Fabio Giovanardi[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: fabio.giovanardi@inaf.it

The rapid growth of satellite constellations in low Earth orbit is creating new challenges for protecting radio astronomy from radio frequency interference (RFI). As the largest radio observatory, the Square Kilometre Array (SKA) demands rigorous even in spectrum management to secure its scientific potential. The European Committee on Radio Astronomy Frequencies (CRAF) strength the collaboration with SKA to preserve the spectrum available to radio astronomy for scientific purposes, continues to engage in international regulatory processes to ensure that the radio spectrum remains a viable resource for cutting-edge scientific discovery.
Agenda Item 1.16 of the next World Radiocommunication Conference planned for 2027 (WRC-27) plays a key role in establishing a regulatory framework that enables the coexistence of non-geostationary satellite services and the Radio Astronomy Service (RAS). Ongoing studies aim to safeguard future astronomical observations by introducing pre-launch regulatory procedures and designating radio-quiet zones around the SKA-Mid and ALMA sites.
At low frequencies, unintended radiated emissions (UEMR), the source of which is still debated, probably due to electronics onboard satellites, represent an additional source of concern. These emissions often fall outside the scope of current compatibility assessments, yet they pose a serious risk to the exceptionally sensitive SKA-Low receivers.
In order to address these challenges, a collaborative approach involving regulators, industry and the scientific community is required to ensure that ambitious projects such as the SKA can achieve their scientific goals.

Topics:

Technology & IT

89

Developing the Italian SKA Regional Centre: Services, Integration, and Future Directions

Author: Giuseppe Tudisco[1]

Co-authors: Fabio Roberto Vitello ; Eva Sciacca [1]; Matteo Stagni [1]; Robert Butora [1]; Alessandra Zanichelli [1]; Vincenzo Galluzzi [1]; Claudio Gheller [1]; Giuliano Taffoni [1]; Andrea Possenti [1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: giuseppe.tudisco@inaf.it

The Square Kilometre Array (SKA) relies on a network of regional centres, known as SKA Regional Centres (SRCs), to manage the vast amounts of data generated by the telescopes, and to provide the global scientific community with seamless access to processing and support services. Each SRC will contribute to this distributed infrastructure by offering data storage, high-performance computing, user services and integration with the global SRC network. In this context, the Italian SKA Regional Centre (ITSRC) is being developed as a full partner in the international SRC network, providing resources and services to researchers in Italy and around the world. An implementation of the ITSRC has been deployed at the Catania Astrophysical Observatory and it's currently undergoing testing as part of the SRC test campaigns. ITSRC will soon be relocated to CINECA, Italy's leading high-performance computing centre, in Bologna. This talk will present the current status of the ITSRC, outline the requirements that have already been met to ensure compliance with the SRCNet 0.1 global specifications, and describe the ITSRC's roadmap, focusing on the planned steps to expand its capabilities in support of future SKA operations.

Topics:

SKA Italy

90

New scaling relations for the galaxy cluster diffuse radio emission

Author: Marco Balboni[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: marco.balboni@inaf.it

The Universe hierarchical formation process can be investigated through the fundamental relations of galaxy cluster observables. Since the matter accretion is gravity-dominated, the hot plasma within galaxy clusters displays a self-similar behaviour, following precise scaling relations that link spatially resolved quantities to global ones. Similarly, the diffuse, non-thermal cluster component (radio halo) is tightly connected to the system properties, with the total radio halo power showing a strong correlation with the system's mass (P - M relation). However, only integrated quantities have been systematically investigated for this component, leaving the non-thermal emission on sub-cluster scales largely unexplored.
In my talk, I address this gap by exploiting the wide and deep radio survey conducted by the SKA pathfinder LOFAR (the LoTSS), which allows for the detection of a large number of radio halos with sufficient angular resolution to characterise in detail their emission.
To this aim, I consider a well selected sample of clusters observed by the LoTSS, also leveraging deep XMM-Newton data from the CHEX-MATE project. I use these data to derive novel scaling relations that link global and spatially resolved radio halo emission with the cluster properties.
Using an analytical model to describe the halo radial profiles, I obtain several key results. I demonstrate how the various features displayed by the halo surface brightness profiles are recovered by properly accounting for the cluster mass and redshift. Furthermore, this analysis provides an assessment of the role of cluster dynamics in shaping the non-thermal emission. By comparing model predictions and observed scaling relations, it also yields constraints on the impact of different radio halo properties, such as the halo average emissivity and the halo size.
Finally, I adopt a physically motivated model to improve the conventional treatment of the observed P-M relation. By explicitly incorporating the magnetic field contribution, this methodology provides, for the first time, a statistical estimate of the average cluster magnetic field. Remarkably, thanks to the novel approach adopted, I can derive a scaling relation between the cluster magnetic field and

its mass, with results that align consistently with independent literature estimates.
The presented analysis shows the great capabilities of the future observations of large samples of objects that will be performed with SKA, allowing for statistical studies of cluster non-thermal emission and deriving constraints on the large scale magnetic field.

Topics:

Galaxy Clusters & LSS (relativistic particles and magnetic fields)

91

SRC-Italy within the federated SRCNet

Authors: Claudio Gheller[1]; Fabio Roberto Vitello[None]; Giuliano Taffoni[1]

Co-authors: Alessandra Zanichelli [1]; Andrea Possenti [1]; Eva Sciacca [1]; Giuseppe Tudisco [1]; Matteo Stagni [1]; Robert Butora [1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: taffoni@oats.inaf.it

The SKA Regional Centre network (SRCNet) is the federated, international layer that brings SKA data and analysis capabilities to researchers worldwide, providing access to data products, platforms near the data, and coordinated user support and training. Within this framework, we present SRC-Italy (INAF) as a node based on INAF computing and storage resources hosted and integrated within CINECA's HPC/cloud ecosystem at the Bologna Tecnopolo, aligning national capacity with a global, interoperable federation that is essential for Science Verification and the ramp-up to operations.
In this talk we outline what an SRC node is for—seamless user access, scalable analysis close to data, reliable data distribution and stewardship, and community enablement—then describe what Italy has been doing: contributing across international SRCNet development teams and holding leadership roles in visualization/deployment workstreams that have informed the v0.1 architecture and prototyping.
Nationally, we have established a dedicated implementation team (INAF, with CINECA as hosting/integration partner) to turn these designs into a working Italian node operated in CINECA's production environment and opened to pilot use with pathfinder/precursor data ahead of SKA Science Verification (2027).
This contribution will discuss the framework of the SRCNet, how SRC-Italy fits organisationally and technically within CINECA, and what value scientists should expect during the pre-operations phase—complementing the detailed infrastructure status/roadmap and science-delivery talks that follow.

Topics:

SKA Italy

92

SKA project status update 2025: seen by the other side of the fence.

Authors: Luca Stringhetti[1]; Marco Bartolini[1]

[1] *SKAO, INAF*

Corresponding Authors: luca.stringhetti@skao.int, marco.bartolini@skao.int

From July 2025, the SKA construction project entered in its 4th year. The first two years were dominated by procurement preparation while the last two years have seen the rise of site activities and actual construction. The Low frequency telescope (SKA Low) reached this year its first staged milestones (Array Assembly 0.5) and the Mid frequency telescope (SKA Mid) will be in a similar position by the end of this year. The talk will present the latest status of the project, the most recent results in the commissioning, and the plan for the remaining years towards completion of the two telescopes. In this talk we would like to offer an insight perspective on the management of this international science project, highlighting the technical challenges and the outstanding technical topics that still remain to be addressed.

Topics:

SKAO General

93

SHORES: Multi-frequency exploration of the faint radio sky

Author: Meriem Behiri[1]

Co-authors: Andrea Lapi [2]; Marcella Massardi [1]; Marika Giulietti [1]; Vincenzo Galluzzi [1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

[2] *SISSA*

Corresponding Author: meriembehiri96@gmail.com

We introduced the Serendipitous H-ATLAS-fields Observations of Radio Extragalactic Sources (SHORES) survey, which targeted 29 fields in total intensity and polarisation within the Herschel-ATLAS Southern Galactic Field. Observations were performed with the Australia Telescope Compact Array in the 2 GHz band, with a central frequency of 2.1 GHz and 2 GHz total bandwidth. Two fields (Deep-1 and Deep-2) were observed to greater depth, while the remaining 27 shallower fields cover ~26 deg², reaching a typical rms of σ ⊠ 33 μJy in the central regions. The Deep-1 field reaches σ ~ 9 μJy/beam, and Deep-2 ~ 18 μJy/beam, with a combined coverage of ~1 deg² at a mean sensitivity of ~13 μJy/beam. Follow-up mosaics at 5.5, 7.25 and 9 GHz reach rms values of 28–39 μJy.

In the shallow component, 2294 sources were detected, with 95% completeness at 497 μJy and reliable counts down to 150 μJy. Thanks to the 6-km ATCA E-W configuration, we achieved angular resolutions of 3.2 × 7.2 arcsec, with 81% of sources remaining unresolved.

In the deep fields, we extracted 489 sources at 2.1 GHz, of which ~100 are also detected at 5.5–9 GHz. Reliability reaches 95% at SNR ~5, while completeness at 95% corresponds to 182 μJy (DEEP-1) and 198 μJy (DEEP-2). The spectral index distribution peaks at $\langle\alpha\rangle \approx -0.7$ with $\sigma \approx 0.3$, dominated by flat-to-steep spectrum sources, while peaked-spectrum sources account for ~16%. About 20% of detections lack FIR counterparts and typically show steep spectra, consistent with a population of FIR-dark galaxies at $z > 3$. Among sources with H-ATLAS counterparts (~19%), most exhibit qFIR > 1.7 and spectral indices typical of star-forming galaxies, indicating that star formation dominates below the mJy level.

Euclidean-normalised differential source counts were derived at 2.1 and 5.5 GHz. At 2.1 GHz, we confirm the transition from AGN to SFG dominance below ~0.5 mJy, in agreement with models such as Mancuso et al. (2017). The 5.5–9 GHz counts provide the first direct constraints on the sub-mJy sky at these frequencies, showing an indication of flattening below ~0.3 mJy.

These results demonstrate the value of deep, multi-frequency radio observations in well-characterised extragalactic fields. SHORES bridges the gap between wide-area shallow surveys and ultra-deep pencil-beam fields, offering new constraints on the relative contributions of star formation and AGN activity in preparation for SKA pathfinders and SKA surveys.

Topics:

Galaxy Evolution & AGN

94

A FLASH on blazars: Capturing the radio realm of 4FGL blazars with SKAO pathfinders

Author: Meriem Behiri[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: mbehiri@sissa.it

We investigate the radio and multi-wavelength properties of 165 blazars from the Fermi-LAT 4FGL catalogue, cross-matched with the ASKAP FLASH continuum survey. The sample includes FSRQs, BL Lacs and blazar candidates of uncertain type, with complementary coverage from RACS, GLEAM-X, AT20G, and ALMACAL, and archival optical/IR and X-ray data.

Radio spectral energy distributions were reconstructed using RadioSED, with at least 5 photometric detections per source. About 50% of the sample exhibit re-triggered peaked spectra, while 14% clearly deviate from this shape. The median rest-frame peak frequency is $\nu_{peak} \approx 4.6$ GHz, with 55% peaking above 10 GHz, consistent with young or recently re-activated blazars. At low frequencies (<100 MHz), the median spectral index is $\alpha \approx -0.54$, indicating extended steep-spectrum emission likely from older lobes.

Strong correlations were identified between radio and gamma-ray luminosities: at 855 MHz, correlation coefficients are $\rho \approx 0.70$ for the full sample, with $\rho = 0.92$ for FSRQs and $\rho = 0.85$ for BL Lacs. The median radio luminosity at 855 MHz is 2.5×10^{26} W Hz^{-1}, while the median gamma-ray luminosity is 4.3×10^{26} W Hz^{-1}. In the radio–X-ray plane (0.2–2.0 keV), a tight correlation is found for FSRQs ($\rho \approx 0.97$ at 855 MHz, $\rho \approx 0.82$ at 20 GHz), contrasting with the scattered behaviour of BL Lacs, reflecting their distinct accretion versus jet-driven regimes.

These results confirm that relativistic jets dominate the radio–gamma connection in blazars, while the radio–X-ray relation highlights differences between FSRQs and BL Lacs. FLASH blazar studies provide critical input for jet physics and AGN evolution, and establish a framework for future large-sample investigations with SKA pathfinders and the SKAO.

Topics:

Galaxy Evolution & AGN

95

From protoclusters to clusters: a preview of the SKA investigation of galaxy evolution in high redshift structures

Author: Maurilio Pannella[1]

Co-authors: Alexandro Saro [1]; Paolo Tozzi [1]; Rosita Paladino [1]; Veronica Strazzullo [1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: maurilio.pannella@inaf.it

I will summarise status and ongoing developments of a project investigating galaxy population properties in massive clusters at z~1.5 and progenitors about 1-1.5 Gyr earlier, in the context of the transition from the proto-cluster to established cluster regimes. In particular, I will present deep MeerKAT observations for both the Spiderweb protocluster and a complete sample of massive (a few times 10 to 14 Solar masses) clusters at z~1.5 that are ICM selected from the SPT-SZ survey. The radio continuum data are unique tools to probe dust-unbiased star formation and nuclear activity in these high-redshift environments, across the cluster virial volume and into the infall region, and in the wide-field structures around protocluster cores. Finally, I will show how this data can also be used, in a novel way, to study the impact of the cluster environments on their galaxy populations.

Topics:

Galaxy Evolution & AGN

97

Active or relics? Searching for remnants among young radio sources

Author: Monica Orienti[1]

Co-authors: Daniele Dallacasa [1]; Filippo D'Ammando [1]; Giulia Migliori [1]; Matteo Murgia [2]

[1] *Istituto Nazionale di Astrofisica (INAF)*

[2] *INAF - OAC*

Corresponding Author: orienti@ira.inaf.it

The evolutionary stage of a powerful radio source originated by an AGN is thought to be related to its linear size. However, the fraction of young radio sources in flux density-limited samples is much larger than what is expected from the number counts of large radio sources, suggesting the existence of short-lived objects and/or intermittency of jet activity. Determining the incidence of young but fading radio sources is thus pivotal for improving our knowledge of the life-cycle of radio emission in radio-loud AGN. Despite its importance for constraining evolutionary models, there are no systematic studies of remnants in complete samples of young radio sources.
In this contribution we will present results on high-resolution multifrequency radio observations of candidate remnants selected from the B3-VLA CSS complete sample. These new observations allow us to constrain the integrated radio spectrum and unveil the presence of active regions. Then we will discuss the observational limitations in inferring the incidence of remnants among young radio sources and how forthcoming radio facilities will circumvent these issues.

Topics:

Galaxy Evolution & AGN

99

Tracing AGN remnant plasma in the SKA era

Author: Marisa Brienza[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: marisa.brienza@inaf.it

Relativistic jets from active galactic nuclei (AGN) inject vast amounts of cosmic rays and magnetic fields into their surroundings—but what happens when the jets switch off? The remnant plasma they leave behind holds crucial clues to the life cycle of radio galaxies and the non-thermal properties of the intergalactic medium, yet it has long remained elusive. In recent years, SKA precursors and pathfinders operating below ~1 GHz have begun to lift the veil on this aged radio-emitting plasma, previously invisible even in well-known systems.
In this talk, I will highlight the importance of studying these sources both through large statistical samples and detailed, multi-frequency analyses of individual systems. First, I will present results from a systematic search for remnant radio galaxies in the LoTSS HETDEX field at 150 MHz, yielding the largest sample to date, with over one hundred candidates. I will discuss the challenges and methods used to identify these elusive objects, and how, when combined with radio galaxy population models, they help statistically constrain the timescales of AGN jet activity. In the second part, I will focus on individual systems with newly detected remnant plasma, showcasing how multi-frequency and spectro-polarimetric observations offer key insights into the jet duty cycle and the physics of the remnant plasma's complex interaction with the surrounding medium, which can at times challenge our theoretical understanding.
Finally, I will discuss optimal observational strategies and the major advances expected from combining SKA-Low and SKA-Mid to capture the most comprehensive picture of this non-thermal component, particularly when used in synergy with facilities such as eROSITA and Euclid.

Topics:

Galaxy Evolution & AGN

100

The contribution of itSRC to SKA Science Delivery: from science data products to community engagement

Author: Vincenzo Galluzzi[1]

Co-authors: Alessandra Zanichelli [1]; Giuseppe Tudisco [1]; Matteo Stagni [1]; Matteo Gandolfi [1]; Fabio Roberto Vitello ; Giuliano Taffoni [1]; Claudio Gheller [1]; Andrea Possenti [1]; Eva Sciacca [1]; Robert Butora [1]; Sara Bertocco [1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: vincenzo.galluzzi@inaf.it

The SKA Regional Centres Network (SRCNet) is the sole interface between the SKA Observatory (SKAO) and the international scientific community. Within this framework, Science Delivery is a core service to support, enable and coordinate the delivery of SKA science, covering many aspects from the generation of science-ready data products to user support and community engagement.
In this talk, we review the Italian node (itSRC) participation in Science Delivery since the earliest activities of the SRCNet, highlighting our collaboration with international teams. Key contributions include addressing the discovery, access, and retrieval of data by defining a metadata model for the scientific exploitation of SKA observations. In collaboration with SKA Project Scientists and Science Working Groups (SWGs), we have also tackled data visualisation and analysis by collecting a preliminary set of science workflows.
The deployment of the itSRC involved both the development and accreditation of a computing infrastructure (see the talk by Tudisco et al.) and extensive data transfer tests within the SKA Data Lake to assess system performance. Our most recent achievement is the successful execution of the v0.1 prototype science test suite on the itSRC infrastructure, a key step in validating the node.
The next phase will be crucial for the SRCNet, and for the itSRC in particular, as we aim to expand engagement with national scientific communities beyond the radio domain. This broader collaboration will drive further improvements to our infrastructure by leveraging the community's scientific expertise, which will in turn maximize the scientific exploitation of the SKA telescopes.

Topics:

SKA Italy

101

Magnetic fields in prestellar cores: a new perspective from meter-wavelength radio data

Author: Andrea Bracco[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: andrea.bracco@inaf.it

Magnetic fields in starless, prestellar cores are crucial for understanding the formation of stars, as these cores mark the initial gravitationally bound stage in the star-formation process. Typically, these cores accumulate gas from their molecular cloud environments until they overcome magneto-turbulent support and collapse into protostellar objects. Traditional studies of magnetic fields in these cores have primarily used indirect methods, such as infrared dust polarization and molecular-line Zeeman splitting. However, these methods have significant limitations, including large uncertainties and issues like magnetic-field dilution due to beam averaging.
In this talk, I propose a novel technique complementary to the infrared band, utilizing non-thermal synchrotron emission detectable in the radio spectrum to trace magnetic fields in prestellar cores. This approach builds on theoretical studies suggesting that cosmic-ray electrons interacting with magnetic fields can produce detectable synchrotron radiation at low radio frequencies (Padovani+2018). I will present an extensive statistical analysis using the LOFAR telescope at 144 MHz, focusing on the median stacking of a large sample of more than 300 prestellar cores in the Perseus molecular cloud (Bracco+2025). While we only achieved upper limits on magnetic field strengths on the order of 100 uG—due to current telescope sensitivity—this method promises a new avenue for studying magnetic fields in molecular clouds with upcoming advanced radio telescopes like the Square Kilometer Array, which could detect such emissions within a few hours of observation.

Topics:

Cradle of Life & Our Galaxy

102

TRAPUM: Pulsar Surveys with MeerKAT and Lessons for the SKA Era

Author: Miquel Colom I Bernadich[1]

[1] *Istituto Nazionale di Astrofisica (INAF)*

Corresponding Author: miquel.colomibernadich@inaf.it

Transients and Pulsars with MeerKAT (TRAPUM) is a collection of pulsar surveys covering globular clusters, the Galactic plane, nearby galaxies, unidentified Fermi sources, and TeV/SNR/PWNe sources in the Milky Way. These surveys are both targeted and wide-field, and they represent the first pulsar searches with an SKA pathfinder, using hundreds of coherent beams during each observation. They have driven advancements in beamforming and distribution, radio-frequency interference mitigation, and precise sky localization of discoveries. However, they also present significant challenges, such as increased data rates and computational demands. Understanding both these opportunities and technical hurdles is a crucial step toward implementing wide-field pulsar searches with future SKA facilities. With more than 270 discoveries, TRAPUM has demonstrated the feasibility and impact of interferometric pulsar surveys, paving the way for pulsar searches in the SKA era.

This talk will review the TRAPUM science objectives, implementation, and results, as well as key lessons learned and their implications for pulsar searches with future SKA facilities.

Topics:

Pulsars & GW detection (PTAs)