The Fourth National Workshop on the SKA Project

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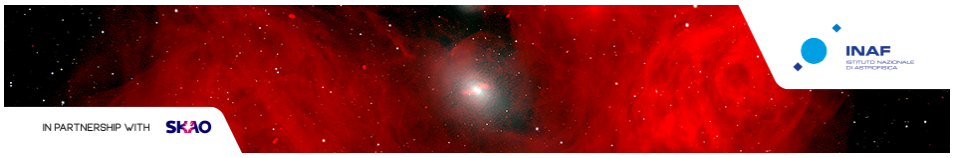
Universita' di Catania, Dipartimento di Fisica



Book of Abstracts

[by speaker alphabetical order]

Parallel - Transients, Pulsars, GW / 13

Recent results of the Large Survey Projects on pulsars at MeerKAT

Author: Federico Abbate[1]

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

Pulsar observations have been an important target for MeerKAT having two Large Survey Projects (MeerTIME and TRAPUM) dedicated to them. This has led to the discovery of more than 200 new pulsars within globular clusters, unidentified Fermi sources, the Magellanic clouds and the Galactic disk. Furthermore, the timing of the known pulsars has led to numerous measurements of neutron star masses, large population studies of pulsars and important results on the properties of globular clusters.
In this talk I will focus on the recent results on pulsar discoveries and timing at MeerKAT and what we have learned from them.

Reasearch area:

Pulsars

Parallel - Transients, Pulsars, GW / 17

The great synergy between SKA and next generation GRB missions

Author: Lorenzo Amati[1]

[1] *INAF .- IASF Bologna*

Next generation GRB space missions like The Transient High-Energy Sky and Early Universe Surveyor (THESEUS), led by INAF and under study by ESA, aim 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 10-12, Pop III stars, 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 '20s / early '30s by next generation facilities like aLIGO/aVirgo, LISA, KAGRA, and 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 a mission like 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 redshift 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.

Reasearch area:

Other

Plenary - SKA-related Technological Activities in Italy / 190

Visualization Tools

Author: Ugo Becciani[1]

Co-authors: Fabio Roberto Vitello ; Giuseppe Tudisco [2]

[1] *INAF*

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

This talk delves into the pivotal role of Visualization Tools within the Square Kilometre Array (SKA) Regional Centres (SRCs). We will explore the groundwork laid by the agile "Orange" team, specifically in their efforts with the prototype "Visualization of SKA data with a high volume of users and a substantial amount of data." The discussion will navigate the intricacies of managing a high volume of users and extensive data, covering key milestones, such as: contribution to defining visualization use cases for SRCNet; comprehensive review of Visualization Tools, including dependencies and interfaces; collection and integration of data products and formats from precursors and pathfinders; adaptation of Visualization Tools to align with SRC architecture and its data lake; testing and deployment of visualization tools and data access services across SRC nodes.
The narrative will conclude with an exploration of the adaptation of VisIVO (Visualization Interface for the Virtual Observatory) for optimal integration within the SRC framework.

Reasearch area:

Other

Parallel - EoR, Cosmology / 3

Large Scale Structure on very large scales: relativistic, wide-angle and the 'finger of the observer' effects

Author: Daniele Bertacca[1]

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

There are multiple reasons for which galaxy clustering requires a proper general relativistic description. (i) We observe events lying on our past light-cone. (ii) The propagation of light is affected by the presence of inhomogeneities in the matter distribution. (iii) In consequence, galaxy observables (i.e. redshift, flux in some wave-band and angular position on the sky) are influenced by the large-scale structure intervening between the source and the observer.
However, when we interpret observations we use an unperturbed FRW model to translate redshifts and fluxes into distances and absolute luminosities. This leads to redshift-space distortions, i.e. the reconstructed galaxy density does not coincide with the actual one. The most important source of the discrepancy is the correction due to the peculiar velocity gradient (Kaiser 1987) but it is long known that there are additional contributions and that they might become significant at large angular separations.
Robust models of galaxy clustering on large scales should thus include these modifications that, most likely, will be key to extracting unbiased information on the dark sector of the Universe (i.e. on the nature of dark energy and dark matter) and to improve constraints on primordial non-Gaussianity.
Recent studies based on analytical calculations and on the Fisher information matrix have concluded that signatures of these additional corrections should be detectable with the next generation of wide-angle surveys. These studies have demonstrated the existence of several additional corrections that, although suppressed on smaller scales, might generate observable signals on distances comparable with the Hubble radius
In this talk I will discuss the LIGER (LIght cones using GEneral Relativity) method, a numerical technique to build mock galaxy catalogues including all general relativistic corrections at linear order in the cosmological perturbations. LIGER post processes the output of a Newtonian simulation and

combines its snapshots at constant background time to build the galaxy distribution in comoving redshift space
Finally I will discuss how the impact of observer velocity on the galaxy clustering measurements is often neglected or only corrected at the redshift level for spectroscopic surveys. In particular, using the LIGER method I will show the impact of the dipole on the monopole of the power spectrum and that it is possible to use the same dipole imprinted on the power spectrum of the galaxy to measure the expansion of the Universe.

Reasearch area:

Cosmology

Parallel - Galaxy Evolution & AGN / 32

The evolution of the ⊠star-⊠⊠⊠ relation: a stacking-derived snapshot at z=0.4 with the MIGHTEE and CHILES survey

Author: Alessandro Bianchetti[1]

Co-authors: Francesco Sinigaglia [2]; Giulia Rodighiero [3]

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[2] *Università degli Studi di Padova*

[3] *University of Padova*

Thanks to MeerKat and the SKA-MID generation, HI is getting accessible at higher z, making it possible to explore galaxy scaling relations involving gas mass at z > 0. Probing the evolutionary path of such relations would allow to understand how cold hydrogen reservoirs impact star formation and galaxy evolution. Recent works exploiting stacking of the 21 cm line with the MIGHTEE survey datacubes, on the COSMOS field, have been unveiling the trends of the HI mass vs stellar mass and SFR at about z 0.4. However, scaling relations built via stacking are typically computed with few data points and would ideally need to be expanded at lower stellar mass to better constrain slope. Employing MIGHTEE HI observations on the COSMOS field in combination with 1000 hrs of VLA observations provided by the CHILES survey ensures a more robust statistics for stacking. We find that star forming galaxies at z≈0.37 are HI-richer with respect to the population at z≈0 and HI-poorer than at higher redshift. Moreover, we find that the tilt of the inferred M*-MHI relation is remarkably compatible with scaling relations extracted at lower and higher redshift.
This supports the idea that galaxies undergo HI depletion with the same rate as a function of cosmic time irrespectively of stellar mass. Though affected by cosmic variance due to the limited sampled volume, we argue that neutral gas flow from surrounding circumgalactic medium might not depend on the stellar mass of the galaxy.

Reasearch area:

HI galaxy science

Parallel - Our Galaxy & Cradle of Life / 48

Shaping the spectroscopic knowledge for SKA-based molecular searches

Author: Mattia Melosso[1]

[1] *Dipartimento di Chimica "Giacomo Ciamician", Università di Bologna*

The frequency coverage of the SKA mid 5 bands (4.6-15.4 GHz) will open a window of unprecedented sensitivity on molecular emission at centimetre wavelengths. In this frequency regime, most of medium size organic species present in the interstellar medium (the so called iCOM) exhibit strong rotational features. These spectra are generally complex, even at moderate temperatures, thus requiring input from very accurate molecular data to be successfully interpreted. Furthermore, at centimetre regimes, low-J transitions of N-bearing species appear as multiplets due to hyperfine interaction, thus contributing to increase the spectral congestion and the difficulty of the analysis. This latter task might be exceedingly difficult for chemically-rich warm sources where many molecules emit simultaneously and the search for novel targets implies dealing with thousands of interfering signals (weeds) generated by less interesting species.
In order to have a spectroscopic database in good shape for the SKA era, a great deal of preparatory work is needed both from the experimental and theoretical side. In the Rot&Comp laboratory at University of Bologna we investigate astrochemically important systems through a close interplay between theory and experiments. High-level quantum chemical calculations are used to derive accurate estimate of molecular properties and to infer thermochemical and kinetics reaction data; for key species, very precise spectroscopic data (up to 1 part to 10^9 for rest-frequencies) are obtained by direct measurements of the relevant spectra in the laboratory.
In this talk, I describe this approach highlighting a strategy to evaluate and improve the quality of spectroscopic knowledge which are deemed critical for pursuing the objectives of the "Cradle of Life"program.

Reasearch area:

Cradle of Life

Parallel - Galaxy Clusters & Magnetism / 30

The key role of magnetic field to disentangle radio emission in the mini halo of RBS797

Author: Annalisa Bonafede[1]

[1] *Bologna University & INAF*

In this talk, I will present are results from LOFAR HBA observations of the mini halo in the clutter RBS797
The cluster is known to host a powerful AGN at its centre with two pairs of jet propagating in orthogonal directions. We have investigated the radio emission, classified as radio min halo, and its connection with the central AGN.
We have found an unexpected trend for the spectral index behaviour of the min halo, and propose three different scenarios to explain it. A detailed knowledge of the magnetic field would be fundamental to discriminate between the three scenarios. I will then show preliminary results on the cluster A2034, demonstrating the power of MeerKAT L-band observations to constrain magnetic fields in galaxy clusters.

Reasearch area:

Magnetism

Parallel - Galaxy Evolution & AGN / 14

The LOFAR view of the Euclid Deep Field North

Author: Marco Bondi[1]

[1] *INAF-IRA*

LOFAR has proved to be one on the most successful SKA pathfinder in the Northern emisphere opening up a poorly investigated radio window providing observations with unprecedented sensitivity and resolution, in particular with the addition of the International Stations.
During the past year the International LOFAR Telescope (ILT, aka LOFAR-VLBI) data analysis has been greatly improved and refined reaching sub-arcsec resolution imaging at 144 MHz with noise of a few tens of microJy/beam (for an 8-hr observation) on a routine basis.
The improvement of about a factor of 20 in angular resolution (from 6" of LOFAR to 0".3 of ILT) is fundamental to study the bulk of radio sources detected in the deep fields which are located at redshift about or greater than 1 and, at the same time, to obtain images of the lobes and hotspots of the brightest giant radio galaxies in the field with unprecedented details at this frequency.
The LOFAR Deep Fields are a great opportunity to exploit the sub-arcsecond resolution of the ILT since the main targets of these deep observations are galaxies at z => 1 and the longer observations allow to reach noise level around 10 microJy/beam.
In this talk I will present the results obtained from 72 hours of observation centered on the Euclid Deep Field North (EDFN) in the North Ecliptic Pole (NEP) region. In particular, I will show and discuss some of the deepest ILT images (rms ~15 microJy/beam) obtained so far of high-redshift radio galaxies and bright sub-mm sources in the NEP region.

Reasearch area:

Extragalactic Continuum (galaxies/AGN, galaxy clusters)

Plenary - Scientific Highlights on the Pathway to the SKAO / 185

Galactic science with SKA & precursors: towards the sharpest view of Our Galaxy

Author: Cristobal Bordiu[1]

Co-authors: Adriano Ingallinera [1]; Alan Cosimo Ruggeri [1]; Carla Simona Buemi [1]; Corrado Trigilio [1]; Filomena Bufano [1]; Francesco Cavallaro [1]; Grazia Maria Gloria Umana [1]; Paolo Leto [1]; Sara Loru [1]; Simone Riggi [1]

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

Galactic science in the radio domain stands at the brink of a profound revolution, thanks to the impressive leap forward in resolution and sensitivity afforded by SKA precursors. To harness this transformative potential, the Our Galaxy working group emerges as a key collaborative hub within the SKA community, bringing together experts from multiple areas.

In this talk, we will offer a concise snapshot of the current "Galactic landscape", focusing on the most urging open questions, from star formation and evolution to Galactic structure. Then, we will review some of the most impactful results achieved with SKA precursors and pathfinders in recent years. Finally, we will assess the prospects for SKA Galactic science in the years to come, exploring possible synergies within the SKA community and with other instruments.

Reasearch area:

Our Galaxy

Parallel - Galaxy Evolution & AGN / 5

ViCTORIA: A MeerKAT survey of the Virgo cluster

Author: Alessandro Boselli[1]

[1] *Laboratoire d'Astrophysique de Marseille, France, scientific associate INAF presso Osservatorio astronomico di Cagliari*

I will describe the ViCTORIA (Virgo Cluster multi Telescope Observations in Radio of Interacting galaxies and AGN) project, a blind survey of the Virgo cluster undertaken with MeerKAT at 21 cm. The survey covers the cluster up to ~ 1 R_200 (60 sq. deg.) and has a sensitivity of ~ 0.6 mJy/beam at 11 km/s and 12x27 arcsec angular resolution. This survey is providing us with a unique set of HI and radio continuum data for hundreds of galaxies within the cluster. Combined with those gathered with LOFAR (Edler et al. 2023) it will provide a unique view of the radio properties of galaxies in a rich environment. I will review
the first results obtained after the analysis of representative objects, and explain as this unique dataset, combined with other data available at different wavelengths, will be used to study the effects of the cluster environment on galaxy evolution.

Reasearch area:

HI galaxy science

Plenary - Scientific Highlights on the Pathway to the SKAO / 23

Paving the way to SKA observations of galaxy clusters with pathfinder and precursor instruments

Author: Andrea Botteon[1]

[1] *INAF-IRA*

Understanding the origin of non-thermal phenomena in galaxy clusters is one of the primary scientific objectives of the SKA. In my talk, I will report on results based on observations of clusters with SKA pathfinder and precursor instruments, focusing in particular on recent discoveries that represent the ground floor for the future exploration of these objects with SKA.

Reasearch area:

Extragalactic Continuum (galaxies/AGN, galaxy clusters)

Parallel - EoR, Cosmology / 6

21cmEMU: an emulator of 21cmFAST summary observables

Author: Daniela Breitman[1]

[1] *Scuola Normale Superiore (SNS)*

Recent years have witnessed rapid progress in observations of the Epoch of Reionization (EoR). These have enabled high-dimensional inference of galaxy and intergalactic medium (IGM) properties during the first billion years of our Universe. However, even using efficient, semi-numerical simulations,

traditional inference approaches that compute 3D lightcones on-the-fly can take 10^5 core hours.
%
Here we present 21cmEMU: an emulator of several summary observables from the popular 21cmFAST simulation code. 21cmEMU takes as input nine parameters characterizing EoR galaxies, and outputs the following summary statistics: (i) the IGM mean neutral fraction; (ii) the 21-cm power spectrum; (iii) the 21-cm spin temperature; (iv) the sky-averaged (global) 21-cm signal; (vi) the ultraviolet (UV) luminosity functions (LFs); and (vii) the Thomson scattering optical depth to the cosmic microwave background (CMB). All observables are predicted with sub-percent median accuracy, with a reduction of the computational cost by a factor of over 10000.

After validating inference results, we showcase a few applications including: (i) quantifying the relative constraining power of different observational datasets; (ii) seeing how recent claims of a late EoR impact previous inferences; and (iii) forecasting upcoming constraints from the sixth observing season of the Hydrogen Epoch of Reionization Array (HERA) telescope.

21cmEMU is publicly-available, and is included as an alternative simulator in the public 21CMMC sampler.

Reasearch area:

Epoch of Reionization

Parallel - Galaxy Clusters & Magnetism / 4

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

Author: Marisa Brienza[1]

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

Jetted Active Galactic Nuclei (AGN) recurrently inflate lobes of relativistic plasma and magnetic fields, which are thought to rise buoyantly as light bubbles into the intragroup/intracluster medium, counterbalancing its spontaneous cooling. Understanding how these bubbles evolve and eventually mix with the surrounding gas on long timescales is important to constrain the impact they have on the thermal and non-thermal history of the system. Direct observations of this phenomenon have always been challenging but, thanks to the SKA precursors/pathfinders, in recent years, we are taking major steps forward.
With four distinct generations of radio lobes, the galaxy MCG+05-10-007, at the center of the group Nest200047, represents one of the clearest pieces of evidence of the recurrent nature of AGN jets and shows, for the first time, that even after hundreds of Myr the AGN jet-inflated bubbles can still be not thoroughly mixed with the intragroup medium. Instead, they can be shredded into intricate filamentary structures, whose physics is still puzzling. Here, I present a broad-band resolved spectro-polarimetric analysis of this system, performed using data from our multi-frequency campaign spanning from 53 to 1500 MHz using LOFAR, uGMRT, MeerKAT, and VLA telescopes. Through the use of techniques such as spectral index maps, color-color plots, shift-plots and Faraday Rotation, we obtain unique insights into the physics of the system including the AGN duty-cycle, the nature of the filaments, and the role of magnetic fields in the plasma evolution. The study clearly shows the power of the combined use of high-quality, new-generation radio data and anticipates the new opportunities offered by the SKA observatory.

Reasearch area:

Extragalactic Continuum (galaxies/AGN, galaxy clusters)

Plenary - The SKA Observatory and the Italian involvement / 166

LOFAR and the the Italian involvement

Author: Gianfranco Brunetti[1]

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

LOFAR is largest pathfinder of the SKA-low, achieving sensitivity and angular resolution 100 times better than in past instruments, LOFAR is opening a new observational window at the low radio frequencies.
Italy, led by INAF, has been a member of the International LOFAR Telescope since the second half of 2018 and since then the Italian community has become one of the most important communities within the collaboration.
In this talk I will summarize the main potential of the instrument and its future roadmap, and I will focus on the scientific and technological contribution of our community.

Reasearch area:

Other

Parallel - Galaxy Evolution & AGN / 47

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

Author: Gabriele Bruni[1]

Co-author: Francesca Panessa [2]

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

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

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

Reasearch area:

Extragalactic Continuum (galaxies/AGN, galaxy clusters)

Parallel - Transients, Pulsars, GW / 46

A faint persistent radio source associated to FRB20201124A

Author: Gabriele Bruni[1]

Co-authors: Chiara Feruglio [2]; Eliana Palazzi [2]; Luciano Nicastro [2]; Luigi Piro [2]

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

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

We present the results of a campaign of observations, aimed at disclosing the origin of a persistent and extended radio emission embedding FRB 20201124A as found in Piro et al. 2021. New high resolution VLA observations show the presence on a flat-spectrum compact source coincident with the position of the FRB, that dominates the radio emission above 10 GHz. Spectral-imaging obtained with the Integral Field Unit MEGARA at the GCT does not exhibit any significant enhancement of luminous (as derived from Hα) or obscured star formation (as derived from Hα/Hβ) at the position of the compact radio source. On the contrary Hα is well correlated with low- frequency radio emission, confirming its association with star formation. Upper limits from NOEMA at 250 GHz imply a conservative upper limit of about 2 M⊙yr−1 at the position of the compact source, in contrast with the >3 M⊙yr−1 value expected if the radio flux of this source were produced by star formation. We conclude that compact flat radio source is likely associated to the central engine of the FRB, with a possible origin from a remnant of a magnetar, a compact merger or X-ray binary.

Reasearch area:

Transients

Parallel - Galaxy Clusters & Magnetism / 22

Recovering diffuse extended emission in the SKA era

Author: Luca Bruno[1]

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

LOFAR is the most important pathfinder of SKA-low observing the radio sky at long wavelengths. One of the aims of both instruments is the study of diffuse synchrotron radio emission from galaxy clusters, such as radio halos that typically extend on large angular (~2'-20') scales. The LOFAR Two Meter Sky Survey (LoTSS-DR2) recently provided the largest sample (309 targets) of mass-selected clusters ever observed at radio frequencies. In a sub-sample of 140 clusters, no radio halos are detected, which may be explained as intrinsic absence of radio emission or extrinsic instrumental/observational limits.

For this sub-sample, we simulated radio halos by injecting mock visibilities into the observed uv-datasets. While previous-generation interferometers (e.g. VLA, GMRT) are highly sensitive to losses of flux density associated with missing short baselines, we showed that a standard LoTSS pointing can fully recover targets up to scales of ~15' thanks to its unprecedentedly dense inner uv-coverage.

Furthermore, the injection technique can be used to derive upper limits to the radio powers of possible halos, which are fundamental when compared with detections in statistical analysis of clusters. We obtained an empirical relation that allows us to rapidly constrain the level of the upper limit based on the image noise and extent of the mock halo, thus dramatically reducing the number of injection cycles and required computing time with respect to standard procedures.

Very large samples of clusters will be soon provided by SKA surveys. I will summarize the results achieved for LoTSS-DR2 clusters and present our public and flexible injection code, which are important starting points to refine strategies that allow to efficiently deal with forthcoming non-detections in SKA observations.

Reasearch area:

Extragalactic Continuum (galaxies/AGN, galaxy clusters)

Parallel - Our Galaxy & Cradle of Life / 186

New Galactic Plane Surveys with SKA precursors: the SARAO GPS with MeerKAT and the SNR use case

Authors: Filomena Bufano[1]; Francesco Cavallaro[1]; Grazia Maria Gloria Umana[1]

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

Deep radio continuum surveys are an essential tool for the study of the different populations of Galactic radio-emitting objects. So far, however, statistical studies of these families are severely affected by selection effects due to the limited capabilities of existing surveys, which undermine the detection of the shallowest and most extended sources. This observational bias results in an underestimation of the studied populations with respect to the theoretical predictions.

In this context, ASKAP and MeerKAT, thanks to their high sensitivity, resolution and uv-coverage, come to fill this gap.

In this talk we will present the MeerKAT Galactic Plane Survey (MGPS), that surveyed, with a mosaic pointing scheme that achieves 1 hour integration time per pointing, a strip of the Southern Galactic Plane (4th quadrant, and also portions of the 3rd and 1st: $248^\circ < l < 61^\circ$, $|b| < 1.5^\circ$).

We will present the project and its status, while showing some highlights from the survey to illustrate the data quality, scientific results and the different source populations discovered in MGPS, will be also presented.

Moreover, in this talk, we will focus on the study of Galactic SNRs, presenting the results obtained with data from the MeerKAT SARAO Galactic Plane Survey and the ASKAP Evolutionary Map of the Universe. We will present new SNRs from the ASKAP Pilot2, highlighting the potential of SKA precursors for the discovery of candidate objects and show some interesting cases found in a sample of 28 known SNRs, for which we could produce integrated and spatially resolved spectra combining SGPS and MWA data, providing deeper insights into their morphology and physics.

Reasearch area:

Our Galaxy

Plenary - Scientific Highlights on the Pathway to the SKAO / 162

Pulsars science towards the SKA

Author: Marta Burgay[1]

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

Pulsars, thanks to their extreme physical conditions and their clock-like nature, are amazing cosmic laboratories for many fileds of astrophysics and fundamental physics. In this talk I will describe the importance of pulsar studies in the context of the Square Kilometre Array and its precursosrs, highlighting some of the most recent results and the open questions that the SKA will help answering.

Reasearch area:

Pulsars

Parallel - EoR, Cosmology / 2

Ongoing efforts for performing Hydrogen Intensity Mapping with MeerKAT

Author: Isabella Paola Carucci[1]

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

Probing the Universe's large-scale structure (LSS) leads to a wealth of cosmological information. With the advent of the SKA Observatory, we can start using the neutral hydrogen (HI) 21-cm emission to trace the LSS. In particular, a novel observational strategy is catching on: Intensity Mapping (IM). With IM, we relax the requirement of source detection and go after all the integrated 21-cm emissions: we can produce detailed three-dimensional maps of a good fraction of the observable Universe. On the one hand, this strategy carries a potentially revolutionary science output. But, on the other, these observations have been extremely challenging to perform. In particular, disentangling the HI IM signal from orders-of-magnitude more intense and intricate contaminants is the thorniest problem. In this talk, I will discuss how we address this challenge with first-of-their-kind observational data from the MeerKAT radio telescope, a precursor to the SKA Observatory. 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.

Reasearch area:

Cosmology

Parallel - Galaxy Evolution & AGN / 25

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

Author: Viviana Casasola[1]

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

Observations of the interstellar medium (ISM) are key to deciphering the physical processes regulating star formation in galaxies, one of the main drivers of galaxy evolution. The mechanisms that transform the overall galactic gas content into stars, such as gas accretion and outflows, control star formation in typical nearby galaxies.

Only a large and coherent dataset of all components of the ISM (atomic and molecular gas, dust, and metals) can provide a definitive view of the ISM in galaxies. By producing an unprecedented set of scaling relations between the various components of ISM e other main galaxy properties (e.g., stellar mass, star-formation rate) in DustPedia galaxies, we found strong indications that the role of HI in regulating star formation may have been down-played so far. While at global scales the role of the atomic gas is well-defined, high resolution HI maps can allow us to re-define it at intrinsic scales of the star formation process.

I will present **MeerKAT** HI data of NGC 1365, also known as the Great Barred Spiral Galaxy, a double-barred prominent spiral galaxy belonging to the Fornax cluster. I will compare these **MeerKAT** HI

data with the molecular gas (ALMA), dust (DustPedia), and gas-phase metallicity ones, drawing conclusions on the interplay between the various ISM components in NGC 1365.

Exploring the cosmic evolution of the gas content of galaxies is a key science driver for **SKA**. High sensitivity and high angular resolution observations of HI in nearby galaxies will definitively clarify the role of HI in the star formation process and will serve as a unique test bed for the upcoming surveys with **SKA**.

Reasearch area:

HI galaxy science

Plenary: Reports from Parallel Sessions / **99**

Galaxy Clusters & Magnetism

Authors: Rossella Cassano[1]; Valentina Vacca[2]

[1] *INAF*

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

Parallel - Transients, Pulsars, GW / **54**

Results from the search for very-low frequency gravitational waves with the EPTA DR2 and InPTA DR1

Author: Aurélien Chalumeau[1]

[1] *Università degli Studi di Milano-Bicocca*

The European Pulsar Timing Array (EPTA) and Indian Pulsar Timing Array (InPTA) collaborations have measured a very-low frequency (~ nano-Hertz) common signal with correlation properties compatible with a gravitational wave (GW) signal. In this talk, I will first describe the methodology and outcome of the pulsar timing and noise analysis applied to the EPTA and InPTA combined data. Then I will present the results from the GW search for either the stochastic background or a continuous GW search using this data set. I will conclude my presentation with prospects on the upcoming International Pulsar Timing Array Data Release 3 that will include data from Square Kilometer Array precursors.

Reasearch area:

Gravitational Waves

Parallel - Our Galaxy & Cradle of Life / **188**

The SKA Working Group Cradle of Life - Where we arrived, what we planned

Authors: Claudio Codella[1]; Eleonora Bianchi[2]

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In a nutshell, the SKA Working Group called Cradle of Life aims to understand how the SKA can be used to observe the earliest stages of the raw material for planet formation, allowing, at the same time, deep
searches for prebiotic molecules (such as amino acids) both within and beyond our solar system. In this
contribution, the preparatory work carried on in the last years by the SKA WG Cradle of Life will be
reported, with a special emphasis on the observations performed at cm-wavelengths in both continuum and
lines. The SKA1 Science Use Cases in the Cradle of Life context will be briefly introduced. The status on
simulations and laboratory experiments will be also outlined.

Reasearch area:

Cradle of Life

Plenary - Scientific Highlights on the Pathway to the SKAO / 161

Astrochemistry of protoplanetary disks on the Solar System scale: living ALMA, preparing SKA

Author: Claudio Codella[1]

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

The ingredients for the recipe to make a habitable planet like our own Earth are: a small rocky planet at the right distance from the host star for water to be in the liquid state, and with an atmosphere organic-rich in volatiles, capable of developing organic molecules chemistry. Searches for exoplanets have shown a large degree of diversity in the planetary systems. It is yet unclear how common a System like our own is. Understanding the formation of planetary systems and the chemical processing that will form their atmospheres is key to understanding the origins of the Solar System. Key questions still to be addressed are: how chemically organic complex are the volatiles delivered to the pristine planetary atmospheres? What molecules are passed from the large-scale envelope to the disk in which planets, comets, and asteroids form? Where do organic complex species form? These are key questions in the context of the SKA WG Cradle of Life.

Astrochemistry of Galactic regions is living a golden age. The study of the so-called interstellar Complex Organic Molecules (iCOMs, mainly O-bearing species with at least 6 atoms), considered the simplest bricks needed to have pre-biotic environments, has benefited of recent improvements of observational tools. The advent of the ALMA (sub-)mm interferometer, with its unique combination of high sensitivity, high angular resolution, and large spectral coverage, boosted both the detections of iCOMs and small C-species and the imaging of their spatial distributions. However, ALMA is unable to survey the chemistry of the protostellar disk midplane where planets will eventually form, because the line emission is absorbed by the optically thick continuum at (sub)mm-wavelengths. In addition, the spectral windows accessible by ALMA do not contain bright lines of heavy molecules (e.g. chains with more than seven C-atoms). Their observations are expected to add an important piece of the overall puzzle as they might have a crucial role in the heritage of organic material from the pre- and proto-stellar phase to the objects of the newly formed planetary system, like asteroids and comets. Those are limits of the ALMA datasets that further sub-mm observations will never overcome. Only high spatial resolution (< 10 au) observations at much lower frequencies, at cm wavelengths, where the dust continuum is more likely to be optically thin, will be able to provide the answer.

Reasearch area:

Cradle of Life

Parallel - EoR, Cosmology / 62

Multi-wavelength forward-modeling of the EoR and cosmic dawn

Author: James Davies[1]

[1] *Scuola Normale Superiore*

In the near future, 21cm cosmology will give us unprecedented insight into the early universe, however the novel nature of this probe makes it difficult to validate our observations. One way to ensure our measurements are correct is to cross-correlate them with other wavelengths. This process will require a fast, flexible forward model which can self-consistently produce mock data of the 21cm signal as well as various signals at other wavelengths. To this end we have extended the popular semi-numerical simulation code 21cmFAST to include a stochastic source model which explicitly tracks halos and galaxies over cosmic time. Using this model, we can produce lightcones of large-scale fields which depend on galaxy properties, such as galaxy number density fields, CII line intensity maps, and the X-ray background. The statistics of these fields, and their cross correlation with the 21cm brightness temperature, can be included in our inference pipeline, tightening our constraints on the nature of the first galaxies, and allowing a vital sanity check on the first measurements from radio interferometers.

Reasearch area:

Epoch of Reionization

Plenary - SKA-related Technological Activities in Italy / 170

From LOFAR to LOFAR 2.0: current and future surveys at the lowest frequencies

Author: Francesco De Gasperin[1]

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

In these talk I will review the successful story of LOFAR, covering a decade of important scientific results obtained with low-frequency radio observations with a particular focus on radio surveys. I will then introduce the LOFAR 2.0 upgrade and the expected improvement in terms of data quality and scientific outcome. The upgrade is aimed at leverage the existing hardware, software and community while remaining impactful well into the SKA era. Finally, I will outline possible synergies between LOFAR and SKA (and its precursors).

Reasearch area:

Other

Parallel - Galaxy Clusters & Magnetism / 34

An ILT view of radio galaxies in Abell 2255: a scientific and technical challenge towards the SKA era

Author: Emanuele De Rubeis[1]

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

The LOw Frequency Array (LOFAR) is an interferometer that operates at frequencies between 10 and 240 MHz. The facility consists of 52 stations. 14 "international"stations are spread throughout Europe: they provide baselines of up to 1989 km, which yields an angular resolution of 0.27"at 150 MHz. Using the full International LOFAR Telescope (ILT) is however technically challenging in terms of both calibration and data volumes: these difficulties caused the ILT to be not intensively used in the previous years, and so just a small number of publications was produced.
The turning point is represented by the development of a pipeline by Morabito et al. (2022) which allows the calibration and imaging of targets within LOFAR's field of view at sub-arcsecond resolution.

I will show the results from the ILT observations of the galaxy cluster Abell 2255. In particular, the main focus is on the "tails"of the four main radio galaxies that characterize the cluster environment, namely the "Original Tailed Radio Galaxy (Original TRG)", the "Goldfish", the "Beaver", and the "Embryo".
These head-tails show extended synchrotron radio emission on 100s kpc-Mpc scales at 144 MHz up to resolutions of 5.0"x 3.8"(Botteon et al., 2020). But, at this moment, no LOFAR-VLBI observations at sub-arcsecond resolution have been performed for these radio galaxies to study their interplay with the merging cluster environment and try to reveal the nature of their filamentary structure. Particular attention is given on the data handling, that represent a crucial point for the correct exploitation of the "international stations"(IS), as well as an important testing ground for the future SKA infrastructure.

The goal of this work is then to use LOFAR long-baselines data to study the structure of the main tails observed in A2255. These preliminary results have been obtained with just a small number of observations (64 hours at the moment) with respect to the huge amount of data that will be available and will be put together (around 250h of observations) in the following months, with the aim to show a unique view of these sources at arc-second and sub-arcsecond resolution.

Reasearch area:

Extragalactic Continuum (galaxies/AGN, galaxy clusters)

Plenary - Scientific Highlights on the Pathway to the SKAO / 192

Tracing the cosmic assembly of supermassive black holes and galaxies in the SKA era

Author: Ivan Delvecchio[1]

[1] *INAF-OAB*

With its unparalleled combination of survey speed, angular resolution and sensitivity, the SKA promises to revolutionize our view of galaxy and supermassive black hole assembly over cosmic time. In this review talk, I will touch upon some key results obtained so far from radio-continuum surveys of SKA pathfinders and precursors. These were broadly aimed at: (i) calibrating radio-continuum as a star formation rate tracer to take a census of the star formation history in the Universe; (ii) assessing the incidence, evolution and impact of radio-emitting Active Galactic Nuclei (AGN), as a function of galaxy and environmental properties. These key topics set the stage for the main science drivers of the upcoming SKA. Finally, I will highlight the expected improvement firstly enabled by the SKA, and its synergic role to other multi-wavelength facilities.

Reasearch area:

Extragalactic Continuum (galaxies/AGN, galaxy clusters)

Plenary - The SKA Observatory and the Italian involvement / 183

SKA Observation Management and Control Software: the italian contribution

Authors: Mauro Dolci[1]; Valentina Alberti[1]; Carlo Baffa[1]; Matteo Canzari[1]; Matteo Di Carlo[1]; Elisabetta Giani[1]; Gianluca Marotta[1]; Teresa Pulvirenti[1]

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A brief overview of the development activities of the SKA Observation Management and Control (OMC) software, based on the TANGO framework, is given. INAF collaborates in the creation of this immense software structure with a number of researchers and technologists with recognized experience in TANGO. They mainly deal with the CSP Local Monitoring and Control (CSP.LMC) system, the TARANTA platform for the Graphical User Interfaces (GUIs) generation, and the system-level support for the integration and deployment, as well as for the generic monitoring.
The current state of the work is presented, with particular reference to the upcoming AA0.5 release.

Reasearch area:

Other

Parallel - Transients, Pulsars, GW / 65

On the shoulders of giants: searching for individual supermassive blackhole binaries in the presence of a background

Author: Irene Ferranti[1]

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Pulsar Timing Array (PTA) experiments use well-timed pulsars to probe the gravitational universe at frequencies down to a few nanohertz. This band is populated by gravitational waves emitted by binary systems of supermassive black holes (SMBHBs). The most common signal sought by PTA experiments is a stochastic gravitational wave background, generated by the superposition of hundreds of thousands of these waves arriving from a large population of SMBHBs. However, it is very likely, especially at higher frequencies (>10-8Hz) where the background amplitude decreases, that there will be one or more singularly resolvable signals. Since the SKA will have a much higher sensitivity than current PTAs, especially at high frequencies, it will significantly increase our probability of observing such resolvable sources.
I will present the first results of realistic simulations of PTA data sets in the presence of a single resolvable source. All simulations are based on the second European PTA data release and the analyses focus on the accuracy and precision achieved in parameter estimation and on the subtleties of disentangling a single gravitational wave signal from the stochastic background.

Reasearch area:

Gravitational Waves

Parallel - EoR, Cosmology / 7

Prospects for a Measurement of the 21 cm Galaxy Cross Spectrum with the SKA

Author: Samuel Gagnon-Hartman[1]

[1] *Scuola Normale Superiore di Pisa*

In the coming years, interferometers such as the Square Kilometer Array (SKA) will enable direct detection of the epoch of reionization (EoR), opening the window to a hitherto obscure epoch of cosmic history. First light from the SKA is expected to yield a low signal-to-noise (SNR) measurement of the 21 cm brightness temperature power spectrum and it will be difficult to convince the scientific community that the signal is genuine. Therefore, it is desirable to have a complimentary observation of proven cosmic origin in order to cross-correlate with preliminary 21 cm EoR observations from the SKA. In this talk, we show that a prospective galaxy survey of our design and the 21 cm signal measured by the SKA could produce a cross spectrum measurement of sufficient SNR to convince the scientific community of the cosmic nature of an SKA first light detection.

Reasearch area:

Epoch of Reionization

Parallel - Galaxy Evolution & AGN / 40

Exploring new SHORES

Authors: Andrea Lapi[1]; Marcella Massardi[1]; Meriem Behiri[2]; Vincenzo Galluzzi[1]

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The Serendipitous H-ATLAS fields Observations of Radio Extragalactic Sources (SHORES), led by Principal Investigator Marcella Massardi, is a 2.1 GHz radio survey conducted with the Australia Telescope Compact Array (ATCA). Spanning 30 fields, totalling 15 square degrees in the Herschel-ATLAS Southern Galactic Pole region, SHORES achieves a sensitivity of up to 50 μJy at 5 σ in the SHORES Deep Field. Notably, this field has also been probed at 5.5, 9, and 20 GHz.
This survey is a valuable resource for preparations ahead of forthcoming SKAO observations. Furthermore, SHORES fields have the advantage of multiwavelength ancillary coverage including Herschel far-IR data (H-ATLAS sgp), mid-infrared data (e.g. Spitzer), optical data (e.g. HST) and ASKAP observations. Moreover, SHORES has been observed in polarization, presenting a unique opportunity to investigate polarization properties within radio-loud AGN, star-forming galaxies, and radio-quiet AGN. Our study of galaxy populations in both total intensity and polarization holds significant implications for cosmology, particularly with regard to the influence of AGN and star-forming galaxies on foreground contamination in the Cosmic Microwave Background (CMB) at smaller angular scales.

Reasearch area:

Extragalactic Continuum (galaxies/AGN, galaxy clusters)

Parallel - Transients, Pulsars, GW / 28

Studying the afterglow phase of Gamma-Ray Bursts in radio

Author: Stefano Giarratana[1]

Co-author: Marcello Giroletti [1]

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

Some massive stars end their lives with a catastrophic explosion which leaves behind a spinning, stellar mass black hole or a highly magnetised neutron star. Regardless of the nature of the remnant, this central engine launches two jets of ionised matter which eventually interact with the circum-burst medium through external shocks, producing the so called Gamma-Ray Burst (GRB) afterglow, which can be detected from the very-high energy throughout the whole electromagnetic spectrum. Radio observations, and in particular VLBI, 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 present two representative cases for radio studies of GRBs: GRB201015A and GRB221009A. For the former, interferometric observations were crucial to characterise the density profile of the circum-burst medium; on the other hand, VLBI observations of the brightest GRB of all time, GRB221009A, allow us to constrain the expansion and the proper motion of the centroid. These cases are the tip of the iceberg of a population that can be easily studied with the sensitivity, the angular resolution and the surveying capabilities of the SKA. Finally, I will discuss the impact of SKA on long GRB science.

Reasearch area:

Transients

Parallel - Galaxy Evolution & AGN / 66

Heavily obscured AGN detection with current and future deep radio surveys

Author: Giovanni Mazzolari[1]

Co-authors: Isabella Prandoni [2]; Marcella Brusa [3]; Marco Mignoli [2]; Roberto Gilli [2]

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[3] *Universita' di Bologna & INAF-OAS*

Obscured Active Galactic Nuclei (AGN) are the largest population of accreting supermassive black holes. The demographics of the most heavily obscured nuclei, however, is still largely uncertain, especially at early cosmic times, where they may dominate the whole AGN statistics.

A promising way to select heavily obscured AGN is through their radio emission, which is largely unaffected by obscuration and, for

sufficiently powerful nuclei, can be revealed in excess of that produced by star formation.

In this talk, I will present a detailed investigation of the effectiveness of radio selection to discover heavily obscured AGN.

We first extend AGN population synthesis models of the cosmic X-ray background to the radio band. Then, we make predictions for the major extragalactic fields covered by both deep X-ray and radio data. Our results show that, while X-ray selection is generally more effective in detecting unobscured AGN, radio selection is significantly more effective in detecting the most heavily obscured, Compton-thick AGN. Thousands of Compton-thick nuclei are indeed expected to hide among the sources of popular radio catalogs.

I will finally present expectations for the number of AGN to be detected by the continuum surveys of the Square Kilometer Array Observatory (SKAO). The SKAO is expected to detect more than 2000 AGN at z>6, and even some tens at z>10: half of them are expected to be Compton-thick.

Reasearch area:

Extragalactic Continuum (galaxies/AGN, galaxy clusters)

Parallel - Galaxy Evolution & AGN / 39

The Far-Infrared/Radio Correlation in Strongly Lensed DSFGs: Insights into Galaxy and AGN Co-evolution

Author: Marika Giulietti[1]

[1] *International School of Advanced Studies (SISSA)*

Co-evolutionary models between supermassive black holes and their host galaxies predict that processes involved in the early stages of galaxy formation, such as nuclear activity and star formation, are closely related and coordinated in time. Dusty Star-Forming Galaxies (DSFGs) serve as ideal testing grounds for examining this scenario, as they constitute the bulk population at the peak of cosmic star formation and have been identified as the progenitors of massive quiescent early-type galaxies. In addition, strongly lensed DSFGs present a unique opportunity to explore regions within the luminosity/redshift space that would otherwise be beyond the reach of current instrumentation. This talk will investigate the interplay between nuclear activity and star formation by examining the far-infrared/radio correlation (FIRRC) within a sample of 28 sub-mm-selected, strongly lensed DSFGs at high redshift. Leveraging the magnification effect, we inferred a weak evolution of the FIRRC up to z~4, accompanied by a diminishing trend relative to radio power. These findings will be interpreted within theoretical frameworks of galaxy/AGN co-evolution. In particular, our targets will be compared with a sample of lensed quasars, where the trend of the FIRRC signifies a transition from an earlier phase of dust-obscured star formation to a later phase as radio-loud quasars. The SKA Observatory and its precursor instruments will have a significant impact on this investigation, particularly as they will play a pivotal role in expanding the samples of strongly lensed galaxies, even reaching back to the Epoch of Reionization.

Reasearch area:

Extragalactic Continuum (galaxies/AGN, galaxy clusters)

Plenary - The SKA Observatory and the Italian involvement / 195

The SKAO: Science & Status

Author: Philippa Hartley[1]

[1] *SKAO*

The SKA Observatory (SKAO) is building the two largest radio telescopes in the world, in an international effort to revolutionise our view of the radio sky. Now under construction in South Africa and Australia, the telescopes will respectively cover the low and mid to high radio frequencies. The past few years have seen great progress, and science verification data is anticipated to be available in 2026-27. In this presentation I will share the latest news from the SKAO, highlighting some of the astrophysical questions the SKAO telescopes will help us to answer.

Reasearch area:

Other

Parallel - Galaxy Evolution & AGN / 10

Galaxy dynamics in the era of large HI surveys

Authors: Federico Lelli[1]; Konstantin Haubner[2]

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

[2] *Universita' Firenze*

Radio observations of the HI emission line at 21 cm have been pivotal to establish the dark matter (DM) problem in galaxies, and remain a key tool to test LCDM models of galaxy formation as well as alternative gravitational theories. The HI disk of galaxies typically extends further out than the stellar component, so one can measure extended rotation curves out to large radii, where the DM effect becomes predominant. In this context, the SPARC (Surface Photometry and Accurate Rotation Curves) project has played a key role, collecting HI rotation curves and Spitzer NIR photometry for 175 disk galaxies at z=0.

In this talk, I will review the main results from the SPARC project, such as the dynamical scaling laws of galaxies, and discuss current limitations, such as the data heterogeneity and limited statistics. I will then introduce the SPARC-1k project, which will provide a new database of about 1000 galaxies with HI data from public archives (ASKAP, ATCA, GMRT, VLA, WSRT) and NIR photometry from WISE. SPARC-1k will increase the current sample size by a factor of about six; this is a necessary step to get ready to the orders-of-magnitude increase expected from ongoing and future HI surveys with SKA pathfinders and ultimately with SKA-mid.

Reasearch area:

HI galaxy science

Parallel - Galaxy Evolution & AGN / 1

Radio observations of ram-pressure-stripped tails: a new window into galaxy evolution

Author: Alessandro Ignesti[1]

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

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

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

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

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

Reasearch area:

Extragalactic Continuum (galaxies/AGN, galaxy clusters)

Plenary: Reports from Parallel Sessions / **101**

Our Galaxy & Cradle of Life

Authors: Adriano Ingallinera[1]; Leonardo Testi[2]

Co-author: Grazia Umana [1]

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Plenary - Scientific Highlights on the Pathway to the SKAO / **193**

HI Galaxy Science with SKA and Pathfinders

Author: Federico Lelli[1]

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

The 21-cm line of atomic hydrogen (HI) is a key tool to study multiple aspects of galaxy formation and evolution in a cosmological context. Atomic hydrogen, indeed, dominates the mass budget of the interstellar medium and is the main reservoir for star formation in galaxies. I will review recent

results from ongoing HI surveys with SKA pathfinders and discuss future exciting prospects with SKA-mid. In particular, I will focus on (1) HI content, morphology, and kinematics in different types of galaxies, (2) processes of gas accretion, gas depletion, and gas removal, which are intimately linked with galaxy morphological transformations, (3) rotation curves and mass models of galaxies, which provide key testbeds for dark matter models and alternative gravitational theories.

Reasearch area:

HI galaxy science

Plenary - Scientific Highlights on the Pathway to the SKAO / 191

The magnetized Universe

Author: Francesca Loi[1]

[1] *Università di Bologna & INAF*

Cosmic magnetism is one of the scientific drivers for the SKA. Magnetic fields are indeed ubiquitous in the Universe. Although it is known that their presence has an impact on the physics of the objects that host them, their origin and evolution is still under debated.
In this talk, I will provide an overview of the scientific motivation for the SKA investigation of cosmic magnetism, strategies, and some recent results obtainted with the SKA pathfinders and precursors.

Reasearch area:

Magnetism

Parallel - Galaxy Clusters & Magnetism / 160

First results from the MeerKAT Fornax Survey (broadband continuum data)

Author: Francesca Loi[1]

[1] *Università di Bologna & INAF*

One of the goals of the SKA precursors and pathfinders is to release high sensitivity and high resolution images of the faint polarized sky. This will allow us to constrain the origin and the evolution of large scale magnetic fields and to study in detail the properties of the faint radio sky. In this talk I will show a preview of the challenges and opportunities offered by the SKA1-mid future surveys thanks to the MeerKAT Fornax Survey (MFS). The MFS is a MeerKAT key science project aiming at studying galaxy evolution (through neutral hydrogen) and the Fornax cluster magnetic field (with broad band spectro-polarimetric data) at L-band. The survey is still ongoing and with the broadband data acquired so far we obtained the densest number of polarized sources ever detected, i.e. 80 polarized sources per square degree. This huge number of polarized sources demonstrate the excellent capabilities of the MeerKAT telescope and allowed us to constrain the properties of the faint polarized sources as well as the intervening large scale magnetic fields.

Reasearch area:

Magnetism

Parallel - Galaxy Evolution & AGN / 42

The low HI mass population in the Fornax cluster as never seen before

Author: Alessandro Loni[1]

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

The MeerKAT Fornax Survey has successfully observed the central part of the Fornax cluster with an unprecedented sensitivity and resolution. Reaching a MHI sensitivity of ~10^6M , these data allow us to investigate the low HI mass population of the Fornax cluster.
By analysing deep VST optical images from the Fornax Deep Survey, it is now clear that some of the low-mass HI detections do not have an optical counterpart and are thus clouds of gas floating within the ICM. The remaining low HI mass detections show that only ~6% of dwarf galaxies still host HI, allowing us to measure the timescale (and so the efficiency) of the HI removal in low-mass systems in the Fornax cluster.
The small number of HI-rich dwarfs causes the collapse of the HIMF of galaxies of the Fornax cluster below ~10^7M , which is indicative of how HI removal affects the evolution of low-mass galaxies in clusters.

In this talk I will explore the low HI mass regime that now with MeerKAT and later with SKA is reachable, focusing on the results of the MeerKAT Fornax Survey. Finally. I will also mention the studies on the SFH and the properties of the multi-phase gas of Fornax galaxies that are possible thanks to the availability of ancillary data from MUSE, ALMA and APEX.

The excitement of deep and high resolution data that SKA will provide is high. However, as a precursor of SKA, the MeerKAT telescope already highlights the challenges we will face. The simple question of whether the faint HI emission is a free floating cloud or a faint galaxy would remain unanswered without the availability of deep optical images. Multi-wavelengths data will be essential to be properly equipped in the future exploration of the Universe observed with SKA.

Reasearch area:

HI galaxy science

Plenary - SKA-related Technological Activities in Italy / 53

Results from observations with the SKA-low prototype station Aperture Array Verification System 2: the INAF contribution towards science commissioning

Authors: Giulia Macario[1]; Giuseppe Pupillo[2]; Gianni Bernardi[3]

Co-authors: Paola Di Ninni [4]; Pietro Bolli [4]; Giovanni Comoretto [4]; Andrea Mattana [2]; Jader Monari [2]; Federico Perini [2]; Marco Schiaffino [2]

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The Aperture Array Verification Systems (AAVSs) are full-size SKA-low prototype stations located at the Inyarrimanha Ilgari Bundara, also known as the CSIRO Murchison Radio-astronomy Observatory, site. Each of them is composed of 256 SKALA dual-polarization log-periodic antennas positioned within a circular area of $\sim$40 m in diameter. These stations are designed to assess the SKA-low performance in preparation for its construction. The two most recent and currently operational AAVSs stations are composed of SKALA4.1 antennas, the reference design for SKA- low. In AAVS2 (late 2019-present), antennas are pseudo-randomly distributed, while AAVS3 (September 2023 - Feb 2024) has a different antenna configuration (Vogel layout) and is undergoing a test campaign. Over the next two years, six AAVS stations will be built to form the Array Assembly 0.5 (AA0.5), the first production prototype of the SKA-low telescope.
With this contribution, we will provide an overview of the results obtained over the past four years of activities, based on the analysis of data from AAVS2 observations at various frequencies across the SKA-low band (50-350 MHz). We will present all-sky images and discuss station calibratability, system stability and sensitivity. Furthermore, we will provide recent results that offer an initial validation of the SKA-low station's polarization response, through Intrinsic Cross Polarization maps derived from all-sky AAVS2 observations and their comparison with electromagnetic simulations.
These observational results are highly promising and represent a significant step towards the forthcoming low telescope construction and science.
The INAF observing group has developed strong technical and scientific expertise and will continue to be actively involved in AAVS3, AA0.5 and SKA-low commissioning plans within the next few years.

Reasearch area:

Other

Parallel - Galaxy Evolution & AGN / 8

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

Author: Filippo Maccagni[1]

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

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

Reasearch area:

HI galaxy science

Parallel - Galaxy Clusters & Magnetism / 58

Combining single dish and interferometric observations of galaxy clusters: the case of the cluster CL0217+70

Author: Paolo Marchegiani[1]

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We present the results of observations at the frequency of 1.4 GHz performed with the Sardinia Radio Telescope of the galaxy cluster CL0217+70 and its surrounding region; we combine the obtained results with available interferometric observations at the same frequency performed with the Very Large Array.
We discuss the information that can be derived by combining single dish and interferometric observations, in particular regarding the diffuse emission in the cluster, with special focus on the radio halo, and the magnetization of the environment.
We also report the observation of an extended emission located outside the cluster and having a very large area: we present its properties, and discuss its possible nature.

Reasearch area:

Extragalactic Continuum (galaxies/AGN, galaxy clusters)

Parallel - Transients, Pulsars, GW / 21

Isolated black holes and neutron stars in the Galaxy

Author: Sandro Mereghetti[1]

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It is believed that about $10^8 - 10^9$ old neutron stars and a comparable number of stellar mass black holes are present in the Milky Way. While isolated neutron stars can be detected as rotation-powered pulsars if young and energetic enough, or, less frequently, as thermal X-ray emitters, isolated black holes have up to now escaped firm detection. Our knowledge of stellar mass black holes is mostly based on those found in X-ray binary systems, where accretion from a companion star makes them visible. Recently, astrometric gravitational microlensing techniques have led to the discovery of a few isolated black hole candidates (one of which confirmed by different groups), and many more are expected in the coming years with the advent of new facilities, such as the Roman Space Telescope. Isolated black holes and neutron stars are expected to accrete at low rates from the interstellar medium. Theoretical models, as well as the evidence based on radio observations of X-ray binaries, indicate that the radio band offers the best detection prospects for compact objects with small accretion rates.
The high sensitivity, spatial resolution and wide sky coverage provided by SKA will be crucial to confirm and study isolated black holes and neutron stars found with microlensing, as well as to independently discover new members of these classes.
I will review the current status and discuss how SKA, in synergy with multi-wavelength data from other facilities, can contribute to this field.

Reasearch area:

Pulsars

Plenary: Reports from Parallel Sessions / 97

EoR and Cosmology

Authors: Gianni Bernardi[1]; Stefano Camera[2]

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

[3] *SNS*

Parallel - Galaxy Evolution & AGN / 43

Hotspots as particle acceleration laboratories in the perspective of SKA

Authors: Giulia Migliori[1]; Monica Orienti[2]; Filippo D'Ammando[2]; Gianfranco Brunetti[2]; Karl-Heinz Mack[2]

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Hotspots are bright and compact regions at the edge of powerful radio galaxies which represent the working surface of the supersonic jets produced by an AGN. Their radio to X-ray synchrotron emission proves that particle acceleration is highly efficient in shocks developing hundred-kpc away from the central engine, with particles accelerated to Lorentz factors >10^6-10^7. Moreover, the detection of diffuse optical emission, points to a role of turbulence in re-accelerating particles in the back-flowing plasma. As such, hotspots are excellent laboratories to investigate different mechanisms of particle acceleration. First, I will present the results of our effort to probe the geometry of the hotspot regions and magnetic field configuration, based on JVLA multi-frequency (300 MHz-20 GHz) observations. Then I will discuss progress possible thanks to the huge improvement in sensitivity and angular resolution in the MHz regime of SKA.

Reasearch area:

Extragalactic Continuum (galaxies/AGN, galaxy clusters)

Plenary - The SKA Observatory and the Italian involvement / 59

SKAlow –The INAF contribution

Author: Jader Monari[1]

Co-authors: Alice Tabellini [1]; Andrea Mattana [1]; Carolina Belli [1]; Davide Fierro [1]; Federica Caputo [1]; Federico Perini [1]; Francesco Schilliro' [1]; Gianni Bernardi [2]; Giovanni Comoretto [1]; Giovanni Naldi [3]; Giulia Macario [1]; Giuseppe Pupillo [4]; Letizia Caito [1]; Marco Schiaffino [1]; Monica Alderighi [1]; Paola Di Ninni [1]; Pietro Bolli [1]; Sergio D'Angelo [1]; Simone Chiarucci [1]

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INAF together with several Italian industries, Universities and other research institutes have been involved in this great project since its conception back in 2002.
The first developments occurred in 2004 with the involvement of the Institute of Radio Astronomy in the EC FP6 SKADS project using the large Northern Cross radiotelescope for testing, among others, new technologies to be applied to the new low frequency aperture arrays as the analogue RF optical fibre links and the acquisition and processing systems able to implement the beamforming entirely in the digital domain, both crucial parts of the SKAlow receiving system. In 2009 a national INAF group was created with the participation of colleagues from OAA, OAC, IASF-Mi and external partners from UNIBO, UNIFI, CNR-IEIIT and industries which have given more impetus to Italian technological developments. This cross-national public-private collaboration has allowed INAF to gain a leadership in several technological areas such as the antenna and an original UAV-based test system, the digital acquisition systems and beamforming firmware design. Most of the proposed technologies have been applied to the Aperture Array Verification Program (AAVP-2010) and to the Aperture Array Design Consortium (AADC -2016).

After the System SKA Critical Design Review, the baseline design of the entire SKAlow receiving system is practically “Made in Italy”.

The first Aperture Array Verification System (AAVS1/2/3) prototypes were installed with a great involvement of INAF staff. Furthermore, INAF participated to the first observations, verification and commissioning of these instruments, making a further contribution towards the industrialization phase. Today INAF has a key role for the SKA Low antennas, receivers and signal processing system, and is strongly involved in the construction of the first release of the telescope (AA0.5).

Reasearch area:

Other

Parallel - Transients, Pulsars, GW / 64

Search for gravitational waves from individual massive black hole binaries in MeerTime data

Author: Beatrice Moreschi[1]

[1] *’G. Occhialini’ Dipartimento di Fisica, Università degli Studi di Milano-Bicocca*

Although the recent evidence presented by PTAs is that for a stochastic gravitational wave background (GWB) which was most likely produced by the superimposition of a number of GW signals, simulations of the merger history of supermassive black hole binaries (SMBHBs) suggest a narrow possibility of the detection of some of the most massive or fortunately located individual continuous GW (CGW) sources in the highest precision PTA datasets that are currently being generated. The detection of CGW sources in the nHz regime would go beyond confirming the existence of sub-parsec SMBHBs, and probe their dynamics, as well as provide several tests of fundamental physics.
In this talk, I will present the results of a search for CGWs in the first MeerTime pulsar timing array (MPTA) dataset, consisting of ultra-precise TOAs of 88 MSPs. MeerTime is a large survey project of MeerKAT, one of the most sensitive radio telescopes and a precursor to the Square Kilometer Array (SKA), in South Africa.

Reasearch area:

Gravitational Waves

Plenary - Scientific Highlights on the Pathway to the SKAO / 189

Galactic transients: X-ray binaries: accretion & feedback around stellar-mass compact objects

Author: Sara Elisa Motta[1]

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

The inflow of matter onto astronomical objects is connected to the generation of outflows throughout the Universe on a variety of scales, from proto-planetary disks, to merging neutron star systems and gamma ray bursts, to stellar mass and supermassive black holes.

The matter inflow/outflow processes scale predictably with mass, and proceeds according to the same basic principles around all collapsed objects. Super-massive black holes have driven the evolution of galaxies and regulated star formation through accretion and feedback. In accreting low-mass X-ray binaries - the low-mass counterparts of super-massive black holes - a stellar mass black hole or a neutron star feeds from an accretion disc that is formed by the material stripped from a stellar companion.

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 show bright jets clearly detected in radio. I will focus on black hole X-ray binaries, and I will give an overview of the properties of jets in these systems. I will review the most important science that has been done with the MeerKAT telescope in the X-ray binary field, and I will mention the opportunities that the advent of SKA will offer.

Reasearch area:

Our Galaxy

Plenary - Scientific Highlights on the Pathway to the SKAO / 168

EoR, Cosmic Dawn and the SKA

Author: Steven Murray[1]

[1] *Scuola Normale Superiore*

The first billion years of cosmic history is still essentially uncharted territory, and promises an enticing range of scientific discovery once its frontiers have been breached. After the well-studied epoch of recombination, three major distinct phases of cosmological evolution occur: the so-called Dark Ages which witness the widespread collapse from pristine linearity via dark-matter dominated halo growth, the Cosmic Dawn in which the first luminous sources awaken, and finally the Epoch of Reionisation (EOR) in which the inter-galactic hydrogen is ultimately ionised. The luminous sources from these epochs are being targeted by advanced space telescopes, like JWST, but these are limited to the highly-biased sample of very brightest sources. The SKA will play an absolutely pivotal role in transforming our understanding of the first billion years, by mapping the integrated contribution of all thermal processes over the vast 3D cosmic lightcone, via the 21cm spectral line of neutral hydrogen.

In this talk, I will give an overview of the exciting science awaiting us once we unlock this treasure trove of information. I will also outline the many significant challenges that obstruct this goal, as well as recent advancements and lessons learned from international “pathfinder” experiments that have made great progress towards overcoming these challenges. Finally, I will look to the future, summarizing the prospects for the SKA and the many synergies between the SKA and other probes of Cosmic Dawn.

Reasearch area:

Epoch of Reionization

Parallel - Galaxy Evolution & AGN / 45

VLBI investigation of candidate neutrino emitters

Author: Cristina Nanci[1]

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Theoretical models predict that the inner part of blazar jets is the site
in which particle acceleration takes place and high-energy neutrinos are produced. The high angular resolution observations with the very long baseline interferometer (VLBI) provide crucial tests for the association of neutrinos with blazars. The interest of the multi-messenger community in blazars as possible neutrino counterparts was powered up in 2017 when a high-energy neutrino was detected in close proximity with the blazar TXS 0506+056, which was also flaring in gamma-rays. The VLBI follow-up observations led to the unveiling of VLBI-scales properties in TXS 0506+056 jet potentially connected with the neutrino production. However, since then, the general picture of the origin of the high-energy neutrino and their possible association with gamma-ray blazars (and with their radio behaviours) have not been clarified yet. Moreover, different classes
of objects have been proposed as possible neutrino emitters.
In this context, we aimed to add new pieces to this puzzling scenario with the VLBI investigation of a sample of gamma-ray blazars observed in spatial coincidence with four new neutrino events, detected by the IceCube neutrino observatory between 2019 and 2020. In the near future, the high sensitivity and the large FoV of the Square Kilometre Array (SKA) will allow us to scan the entire neutrino localisation regions, which are of the order of degrees squares, in order to identify all the possible radio counterparts, including low surface brightness and non-blazar sources. The VLBI follow-up observations will subsequently provide detailed VLBI-scales characterization of the SKA-detected candidates, which could lead to ascertaining their connection with the neutrino events and determining radio features in common in neutrino sources. I will present our VLBI results on the four VLBI follow-ups of the neutrino events obtained so far and how the VLBI-SKA synergy will help in the potential candidates identification.

Reasearch area:

VLBI

Parallel - EoR, Cosmology / 52

Extracting the Epoch of Reionization signal for the SKA Foregrounds Data Challenge

Author: Ainulnabilah Nasirudin[1]

[1] *Scuola Normale Superiore*

The objective of the SKA Foregrounds Data Challenge is to evaluate the accuracy of the different techniques used to extract the cylindrically-averaged power spectrum of the Epoch of Reionization signal, clean from foreground contamination. We use the foreground avoidance method to constrain the EoR signal using 21CMMC, whereby only a small part of the EoR window is utilized. We model our sky comprising of just the EoR signal over 8 by 8 degrees and attenuate it by the provided SKA beam. We assume a flat sky approximation to Fourier Transform the sky, before sampling

the visibility cube with the SKA baselines and adding thermal noise. The sampled visibilities are then re-gridded using a Gaussian kernel, and we apply a Blackman-Harris spectral taper. Finally, the 2D power spectrum is computed by cylindrically averaging the re-gridded cube, which is then evaluated against the SKA data using 21CMMC MultiNest sampler. We present the constrained EoR signal devoid of any contamination and instrumentation effect using this method.

Reasearch area:

Epoch of Reionization

Parallel - EoR, Cosmology / 33

Inference and modeling of early galaxy properties: the role of stochacity during EoR.

Author: Ivan Nikolić[1]

[1] *Scuola Normale Superiore Pisa*

Recent years have seen an increase in data probing the Epoch of Reionization (EoR) and nearing Cosmic Dawn, which is set to culminate with the observations from SKA. To accurately interpret these observations, we need to model both large-scale radiation fields and small-scale galaxy physics. The role of stochasticity in these quantities, is often neglected in semi-numerical models. To investigate it we develop a simple and flexible parametric model for galaxy formation, combining it with the public large-scale semi-numerical simulation 21cmFAST. We find that complex star-formation processes and small-scale physics that affects the radiation leaving the galaxies has a large impact on the variance of ionizing and x-ray emissivities which has important consequences for 21cm signal.

Reasearch area:

Epoch of Reionization

Plenary - The SKA Observatory and the Italian involvement / 70

Welcome: INAF President, Catania Obs. Director

Author: Marco Tavani[1]

Co-author: Isabella Pagano [1]

[1] *INAF*

Parallel - Our Galaxy & Cradle of Life / 61

Astrochemistry with SKA: a laboratory perspective on solid-phase pathways and gas-phase detections

Authors: Carlotta Scire' Scappuzzo[1]; Daniele Fulvio[1]; Giuseppe Baratta[1]; Maria Elisabetta Palumbo[1]; Massimo Germanà[2]; Riccardo Giovanni Urso[1]

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The low temperature (<20 K) and high density (n>10^4 cm^-3) of dense molecular clouds cause simple gas-phase species to freeze onto dust grains. The so-formed ices are then subjected to a variety of processes that may increase their chemical complexity. Among them, UV photons and low-energy cosmic rays trigger the formation of both simple and more complex species [1, 2], including interstellar-complex organic molecules (iCOMs), [3]. In the further stages of star-formation, both thermal and non-thermal desorption processes cause the injection of solid-phase compounds into the gas-phase, allowing their detection by means of radiotelescopes [4, 5].
SKA will allow to search for iCOMs in star-forming regions and protoplanetary disks, allowing us to shed light on the chemical complexity and the distribution of molecules in these regions [6, 7].
The Laboratory for Experimental Astrophysics at the INAF-Osservatorio Astrofisico di Catania is currently working on a new experimental setup to simulate the exposure to energetic ions and UV-photons of ices in molecular clouds and to investigate the formation of iCOMs. Ices will be then injected in the gas-phase and analyzed by means of mass spectrometry.
We will show the ongoing activities and some scientific cases that show the importance of solid-phase chemistry in the formation of molecules in star-forming regions.

[1] Rothard, H. et al. 2017, J. of Phys. B, Atom. Molec. Optic. Phys. 50, 6, 062001
[2] Urso, R. G., et al. 2022, A&A, 668, A169
[3] Caselli, P., & Ceccarelli, C. 2012, A&ARv, 20, 56
[4] Palumbo, M.E. et al. 2008, ApJ, 685, 2, 1033
[5] Urso, R.G. et al. 2019, A&A, 628, A72
[6] Codella, C. et al. 2015, AASKA14, 9-13 June 2014, id. 123
[7] Testi, L. et al. 2015, AASKA14, 9-13 June 2014, id. 117

Reasearch area:

Cradle of Life

Parallel - Galaxy Evolution & AGN / 29

Understanding the AGN accretion and ejection physics with SKA

Author: Francesca Panessa[1]

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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 constitute 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 with unprecedented sensitivity and spatial resolution with SKA, in particular by exploiting its VLBI capabilities.

Reasearch area:

Extragalactic Continuum (galaxies/AGN, galaxy clusters)

Parallel - Transients, Pulsars, GW / 67

How many transitional millisecond pulsars are out there?

Author: Alessandro Papitto[1]

Co-authors: Alessio Marino [2]; Arianna Miraval Zanon [3]; Domitilla De Martino [1]; Filippo Ambrosino [1]; Francesco Coti Zelati [2]; Giulia Illiano [4]; Luciano Burderi [5]; Melania Del Santo [1]; Tiziana Di Salvo [6]

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[5] *University of Cagliari*

[6] *University of Palermo*

The discovery of transitional millisecond pulsars demonstrated that slight variations in the mass accretion rate can induce swings between a rotation-powered radio pulsar state and an accretion-powered X-ray pulsar regime. However, ten years after the first transitions seen, these pulsars turned out to be relatively rare. Transiently accreting millisecond pulsars are expected to turn on as rotation-powered systems as soon as they enter into quiescence. However, radio pulsations have been observed only once in spite of many efforts. On the other hand, transitional systems in a low-luminosity accretion regime showed a variable radio emission likely originated in more or less collimated outflows. Yet, transitions to the radio pulsar state have been sporadic. Recently, high-time resolution observations in the optical band widened the spectrum of searches for transitional systems. We will summarize the multi-wavelength efforts paid to catch these rare systems and discuss the role that can be played by the current and next generation of radio and X-ray facilities.

Reasearch area:

Pulsars

Parallel - Galaxy Clusters & Magnetism / 182

Constraining the origin of radio halos in galaxy clusters

Author: Thomas Pasini[1]

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

A number of galaxy clusters show extended, diffuse, synchrotron emission in their central region. These sources are called radio halos, and are produced by the (re-)acceleration of relativistic seed electrons that fill the magnetised plasma halo of galaxy clusters. However, the nature of the re-acceleration mechanism is unclear. The current leading scenario is based on second order Fermi mechanisms, which are poorly efficient and are predicted to generate a large population of radio halos with very steep spectra (□ < -1.5). In this talk, I will present an upcoming study where we provide strong evidence in favour of this scenario, using observations performed with LOFAR. By exploiting survey data from LoTSS and LoLSS of a sample radio halos, we prove for the first time that a large fraction (~65%) shows emission that fades quickly with increasing radio frequency, implying an ultra-steep synchrotron spectrum. In addition, we find a correlation between the cluster mass and the halo spectral index, with more massive clusters hosting flatter halos. The existence of a larger population of ultra-steep spectrum radio halos, with respect to flatter spectrum sources, further validates these models, which predict an increasing fraction of radio halos associated with less massive galaxy clusters.

Reasearch area:

Extragalactic Continuum (galaxies/AGN, galaxy clusters)

Parallel - EoR, Cosmology / 194

Synergies of SKA with high-z galaxy surveys

Author: Laura Pentericci[1]

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In the next decade many new optical/near-IR instruments will become available,
including new MOS facilities with large field of view (MOONS and PFS), the MOSAIC spectrograph on the ELT and the planned 10 mt class dedicated telescopes (WST and MSE).
These will enable large spectroscopic surveys which will allow us to detect and study unprecedented samples of galaxies well into in the epoch of reionization and over very large areas.
I will briefly discuss the synergies between such surveys and SKA to unveal the baryon and energy interchange between galaxies and the intergalactic medium during the process of reionization.

Reasearch area:

Epoch of Reionization

Parallel - Transients, Pulsars, GW / 51

The Large European Array for Pulsars (LEAP) as a precursor of SKA

Author: Delphine Perrodin[1]

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One of the top science goals for the SKA is the study of pulsars, and in particular the use of pulsar timing arrays (PTAs) for the detection of low-frequency gravitational waves (GWs). In 2023, PTA collaborations around the world have revealed evidence for a background of low-frequency GWs, possibly from supermassive black hole binaries or cosmological sources. A higher significance is however needed to confirm this result and to identify its origin. This can be achieved in part by improving the timing sensitivity of pulsar observations. This is the scope of the Large European Array for Pulsars (LEAP), a project of the European Pulsar Timing Array (EPTA) collaboration, which has been ongoing since 2012. It consists in the simultaneous, monthly observing of about 20 pulsars in baseband mode with all five radio telescopes of the EPTA, including the Sardinia Radio Telescope. This setup allows for the coherent addition of the radio pulses, the maximization of the signal-to-noise of pulsar signals and the increased precision in times-of-arrival. Pulsar observing at the EPTA telescopes in simultaneous "LEAP"mode effectively makes LEAP the sixth telescope of the EPTA, and, with a sensitivity that is equivalent to a 194-meter dish and thus equivalent to SKA-1, makes it an efficient precursor to the SKA. LEAP data acquired over the last few years have been included in EPTA datasets. Additionally, access to the combined baseband LEAP data has allowed for the detailed study of pulsar single pulses, giant pulses, pulse micro-structure and interstellar delays, which provide important information to both pulsar and PTA science.

Reasearch area:

Pulsars

Parallel - Galaxy Clusters & Magnetism / 20

Probing diffuse radio emission in bridges between galaxy clusters

Author: Giada Venusta Pignataro[1]

[1] *Università di Bologna*

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

Reasearch area:

Extragalactic Continuum (galaxies/AGN, galaxy clusters)

Plenary - Scientific Highlights on the Pathway to the SKAO / 27

Fast Radio Bursts in the SKA era

Author: Maura Pilia[1]

Co-authors: Gianni Bernardi [1]; Matteo Trudu ; Davide Pelliciari

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Fast Radio Bursts (FRBs) are millisecond-long, coherent radio flashes that exhibit the typical dispersion due to the propagation through an ionised medium. 15 years after their (serendipitous) discovery, we know that their origin is extragalactic, that a fraction of them repeats and, from the localisation of a few of them, that their environment can be quite diverse, ranging from star forming galaxies to globular clusters. Observations of an FRB event from the Galactic magnetar SGR 1935+2154 provided a tempting evidence to identify magnetars as the FRB progenitors, although it become quickly clear that magnetars like SGR 1935 cannot be the sole progenitors of the whole FRB class, requiring different progenitors for different classes of events. Needless to say that the physical mechanism that powers their emission remains largely unconstrained.

The SKA is expected to provide answers to many of the FRB unknowns: it will provide the observation and simultaneous localisation of thousands of events, allowing to study their relation with the environment and, therefore, to pin down the nature of their progenitors; it will enable measurement of their redshifts for cosmological studies, and provide exquisite measurements of their spectro-temporal and polarisation properties.

In this talk I will highlight what are the main advancements in the field that we expect in the SKA era and how the Italian community is getting ready for it through its facilities and building its own expertise in the field.

Reasearch area:

Transients

Plenary - SKA-related Technological Activities in Italy / 164

Updates on the INAF C-band PAF development project

Author: Tonino Pisanu[1]

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In this talk, we will show the status of a C-band Phased Array Feed (PAF) we are developing as part of the SKA Advanced Instrumentation Program (AIP). We are designing a PAF in the frequency range of 4-8 GHz for the primary focus of the Sardinia Radio Telescope (SRT) in order to test all the different technologies needed in the design and construction of a special radio astronomical receiver as a PAF. Starting from the large and complex design of the array of antennas to the highly integrated electronic circuits of the front end, containing the LNAs, filters, and other components, to the very complex back end and digital signal processor. All the most important radio astronomical groups in the world are investing many efforts in the PAF field to develop state-of-the-art cryogenic PAFs for their radio telescopes also in view of a possible development for the SKA-mid antennas.

Reasearch area:

Other

Plenary: Reports from Parallel Sessions / 100

Transients & Pulsars

Author: Marcello Giroletti[1]

Co-author: Andrea Possenti [2]

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

[2] *INAF*

Plenary - The SKA Observatory and the Italian involvement / 163

The Italian SKA Regional Centres: the development plan

Author: Andrea Possenti[1]

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

SKAO is expected to provide the researchers with order 300 PBy/year of data from the SKA low-frequency telescope (SKA-LOW) and 300 PBy/year of data from the SKA high-frequency telescope (SKA-MID) during the first few years of activity. The advanced analysis of all those data will take place within a network of so-called SKA Regional Centres (SRCs), which, under the 'Findable, Accessible, Interoperable, and Reusable'(FAIR) principles, will also take the responsibility for curating and archiving both the Observatory Data Products and user-generated Advanced Data Products, as well as for helping the researchers in the estimate of the needed computational effort at the proposal stage.

This contribution describes the perspectives of the Italian contribution to this international network. An initial SRC Italian node of the global network is expected to be conceived and later established in a 2 timescale. It will primarily focus on by-then existing data, mainly from the SKA precursors and pathfinders.

Reasearch area:

Other

Plenary - The SKA Observatory and the Italian involvement / 184

The SKA Observatory from an Italian Perspective

Author: Isabella Prandoni[1]

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

In this talk I will briefly outline the Italian involvement in the SKA project, with particular emphasis on the ongoing activities in preparation for the science exploitation of the SKA surveys.

Reasearch area:

Other

Plenary: Reports from Parallel Sessions / 98

Galaxy Evolution (RC & HI)

Authors: Isabella Prandoni[1]; Paolo Serra[2]

[1] *INAF*

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

Parallel - EoR, Cosmology / 11

Synergies with sub-mm and mm observations

Author: Giuseppe Puglisi[1]

[1] *University of Catania*

The forthcoming experiments aimed at observing the Cosmic Microwave Background (CMB) polarization (e.g. Simons Observatory, SO and CMB-Stage IV, CMB-S4), are expected to survey half of the sky at frequencies between 30 and 280 GHz and ~1' resolution with an unprecedented sensitivity. Most of the extragalactic detections will employ active galactic nuclei (AGNs) and dusty star-forming galaxies (DSFGs), together with transient sources such as Gamma Ray Burst (GRB) afterglows and Tidal disruption events. This large frequency coverage will complement low frequency radio continuum surveys (e.g., VLA/VLASS, ASKAP/EMU, MeerKAT/MIGHTEE), and it will allow to assess the spectral energy distributions of AGN selected at lower frequencies and observed up to 300 GHz thanks to the large area of overlap among the aforementioned surveys.
In this contribution, we will present the status of SO (whose commissioning phase is about to start early next year) and the CMB-S4 expected timeline (to be deployed in 2027), together with the projected forecasts of the two experiments in terms of AGN detections.
We will devote a specific focus on the synergies with the low-frequency surveys. Particularly, we will show the latest results from literature used to simulate radio galaxies (Li et al 2021, Stein et al. 2020) and the reciprocal complementarity that these co-eval data will represent for both the CMB and the radio communities.

Reasearch area:

Cosmology

Parallel - Our Galaxy & Cradle of Life / 44

Source detection and classification in the SKA precursor era with machine learning

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A new era in radio astronomy has begun as the Square Kilometer Array (SKA) precursors started their planned large area survey programs. Humongous datasets with thousands of sources per square degree are being delivered, requiring a high degree of automation and knowledge extraction to maximize the scientific return. This has fuelled a growing interest in Machine Learning (ML) techniques as a valuable means to deal with such a data deluge for various tasks, such as source detection, object or morphology classification, and anomaly detection. However, the application of these techniques to new generation radio data is not always straightforward and requires considerable efforts and special care, especially if the radio data is to be combined with supplementary multiwavelength information.
In this context, our group is investigating and evaluating the applicability of various state-of-the-art ML methodologies to SKA precursor surveys (ASKAP, MeerKAT), with a special emphasis on Galactic science objectives. In this talk, we will share the results achieved on different scientific use cases, highlighting the encountered challenges and limitations: (1) the search and characterization of radio sources with different morphologies, (2) the classification of Galactic and extragalactic compact sources with multiwavelength data from the near-infrared to the radio, and (3) the unsupervised classification of extended radio sources (supernova remnants, evolved stars).

Reasearch area:

Our Galaxy

Parallel - Galaxy Clusters & Magnetism / 36

Shocks (among us) in the IGrM of HCG15

Author: Christopher Riseley[1]

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

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

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

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

Reasearch area:

Extragalactic Continuum (galaxies/AGN, galaxy clusters)

Parallel - Galaxy Evolution & AGN / 31

Unveiling the atomic gas content of quenched galaxies at 0.2<z<0.5

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We present preliminary results from a HI stacking experiment at 0.2<z<0.5 from the MIGHTEE survey. To complement our studies on main-sequence star-forming galaxies,
we are now interested in statistically comparing the HI gas content in the passive population at similar cosmic epochs, in order to further constrain this un-explored phase of the baryon cycle.
We study in particular the galaxy's high stellar mass-end, M>*10^10Msun at z~0.37, where most of the available quenched objects are detected in COSMOS.*
The wide spectroscopic samples in this field is key to obtaining some meaningful signal.

We will select passive sources mostly from colour-colour selection and from SED fitting physical parameters (M vs SFR).
We have identified a population of passive sources, spectroscopically selected from their D4000 feature, that retain a detectable dust content (from mid- and far-IR counterparts). This sample seems to harbour important HI reservoirs, in quantities even exceeding those of star-forming galaxies at fixed stellar mass. A statistical investigation is required to fully constrain the overall gas content in quenched sources.
We will interpret our results in terms of galaxy morphological and environmental dependences (with many passive sources sitting in groups) and compare them with predictions from the simulations.

Reasearch area:

HI galaxy science

Plenary - The SKA Observatory and the Italian involvement / 171

An overview of INAF's cooperation with South Africa: context, programmes and opportunities

Author: Pierguido Sarti[1]

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South Africa is one of Italy's particularly relevant scientific partners in Africa, due to the strong involvement of a few Departments of the Italian National Institute for Astrophysics - along with other national research and higher education institutions - into the development of the Square Kilometre Array project and its precursors, in cooperation with the South African Radio Astronomy Observatory and several South African universities.
Indeed, radio astronomy represents the core of the scientific cooperation between Italy and South Africa, as the SKA project benefits of the largest financial contribution of the Italian government in scientific activities developed in Sub Saharan Africa.

The cooperation has been supported by several funding schemes promoted by INAF itself, the Italian Ministry of Foreign Affairs and International Cooperation, and by other funding sources, such as the PNRR. Particularly, this latter has allowed the allocation of a significant financial support for the development of a new joint research programme and a mobility scheme between the two countries.

The success of international scientific collaborations (both in bilateral and multilateral contexts) is certainly boosted by a strong political commitment and a close cooperation between the relevant research and government institutions. On a national level these entities must work together to maximize the benefits that the scientific partnerships can realize in science, technology, and innovation, as well as their positive long-term impact on society, industry, infrastructure, and human capacity development.

A clear vision of the context in which international collaborations are developed and evolve, knowing the different stakeholders and precisely understanding their role, the optimal and coordinated use of resources and the dissemination of opportunities and information are key elements of successful scientific partnerships.

This presentation will review the Italy-South Africa bilateral scientific partnership in a science diplomacy perspective, focussing on the cooperation in radio astronomy, the Square Kilometre Array and the ongoing and future programmes and opportunities.

Reasearch area:

Other

Plenary - The SKA Observatory and the Italian involvement / 169

STILES for SKA

Author: Francesco Schilliro'[1]

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Parallel - Galaxy Evolution & AGN / 35

HI morphology as a tracer of environmental interactions: present and future

Author: Paolo Serra[1]

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

HI morphology continues to be a prime tracer of the interaction between galaxies and their environment. I will describe a number of recent and ongoing projects led by INAF researchers, where HI imaging is used to study galaxy quenching inside clusters. These projects include: a blind HI survey of the Coma cluster; HI imaging of jellyfish galaxies as part of GASP; blind HI observations of clusters at z~0.05 performed for the MeerKAT Galaxy Cluster Legacy Survey; ViCTORIA, a survey of Virgo with MeerKAT; and the MeerKAT Fornax Survey. These datasets can be compared with additional ones available for other clusters both from the literature and from other ongoing projects. The emerging picture is a complex one, where the efficiency of HI stripping depends on galaxy properties (mass and orbit) and on cluster properties (ICM density and substructure), and hydrodynamical forces act simultaneously with tidal forces. This leads to a broad variety of HI morphologies and quenching timescales. By combining HI and multi-wavelength data we are learning about the multi-phase properties and the star formation activity both in the disc and the gas tails of the stripped galaxies. Besides stripping, other interesting phenomena are only now starting to be studied, such as the condensation of the ICM in the wake of galaxies moving within a cluster, or the role of magnetic fields in shielding the stripped gas from their hostile environment. This line of research will continue to grow in the SKA era but some challenges will need to be addressed. With the growth of our galaxy samples, clearer criteria for HI morphological classification and/or quantitative HI morphology will need to replace the current visual approach. Furthermore, in order to exploit quantitative morphology, the effect of projection, signal-to-noise ratio and resolution will need to be studied in more detail. Finally, recent observations show that the power of HI morphology as a tracer of environmental interactions is greatly enhanced in a region of the "column density sensitivity vs. physical resolution" plane which is difficult to reach. Future SKA programs interested in this type of science will need to focus on that region.

Reasearch area:

HI galaxy science

Parallel - Transients, Pulsars, GW / 55

Astrophysics from the PTA evidence for the nanohertz gravitational wave background

Author: Golam Mohiuddin Shaifullah[1]

[1] *'G. Occhialini' Dipartimento di Fisica, Università degli Studi di Milano-Bicocca*

I will present the astrophysical interpretations of the recently published evidence for a nanohertz gravitational wave background, as detected by pulsar timing arrays. I will discuss the future of low-frequency gravitational wave astronomy with PTAs and the upcoming contribution of SKA precursors to those datasets.

Reasearch area:

Gravitational Waves

Plenary - Scientific Highlights on the Pathway to the SKAO / **165**

Late-time cosmology with the SKA Observatory

Author: Marta Spinelli[1]

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

The SKA Observatory will play a major role in advancing the field of radio cosmology,
measuring the positions and shapes of galaxies detected from the continuum and performing both galaxy surveys and intensity mapping measurements of the 21cm line of neutral hydrogen. In this talk, I will present the structure of the Cosmology Science Working Group briefly reviewing the status of the science cases of interest for the radio cosmology community, with a focus on the Italian contribution. I will then describe in further detail 21cm Intensity Mapping and discuss how such a technique can open a new observational window on dark matter and dark energy. I will present the current data-taking campaign of the SKAO precursor MeerKAT and the roadmap for the future.

Reasearch area:

Cosmology

Parallel - EoR, Cosmology / **173**

Status of 21 cm global signal measurements

Author: Marta Spinelli[1]

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

Total-power radiometry with individual meter-wave antennas is a potentially effective way to study the Cosmic Dawn through measurement of the sky brightness arising from the 21cm transition of neutral hydrogen, provided this can be disentangled from much stronger Galactic and extra-galactic foregrounds. In this talk, I will review the current observational status of the global signal, 5 years after the EDGES results. I will also discuss some of the approaches/improvements in the analysis pipelines that have been proposed and some of the future directions that are being explored.

Reasearch area:

Epoch of Reionization

Parallel - Galaxy Clusters & Magnetism / 15

Addressing the challenges of deep LOFAR observations of the Coma galaxy cluster

Author: Chiara Stuardi[1]

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

The nearby Coma galaxy cluster is a milestone for studying magnetic fields and particle acceleration processes in the intra-cluster medium (ICM). Recent LOFAR observations at 144 MHz have revealed new features in the extended radio emission of this cluster: a bridge connecting the halo to the cluster, a sharp radio front at the halo's edge, and an intriguing "accretion relic" lying beyond the cluster virial radius.
In this talk, I will present follow-up observations of Coma at 54 MHz, performed with LOFAR Low Band Antennas (54 MHz). Our deep observations (~100 hours) of this complex field (4x4 deg^2 with diffuse emission and bright 3C sources) required a tailored calibration strategy and large computational resources. I will discuss how we can address these challenges today and in view of the SKA. Furthermore, I will show preliminary results obtained from the resolved spectral index study of the diffuse radio emission between 144 MHz and 54 MHz.

Reasearch area:

Extragalactic Continuum (galaxies/AGN, galaxy clusters)

Plenary - The SKA Observatory and the Italian involvement / 71

Institutional Welcome from the University of Catania

Parallel - Our Galaxy & Cradle of Life / 12

Unveiling planet formation with the SKA

Author: Leonardo Testi[1]

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

The last decade has seen a trasformation of the field of planet formation, high angular resolution images and surveys with ALMA and the VLT telescopes have drastically changed our view of protoplanetary disk evolution. The main results are: the realization that planets form on timescales much faster than previously thought and the detection and characterization of the first protoplanets embedded in disks and the disk-planet interaction, which is thought to shape disk and planets evolution and determine the diversity of exoplanets architectures. These results have also highlighted and enhanced the expectations on the SKA contribution. While the basic contributions from SKA outlines in the Testi et al. (2015) contribution to the SKA Science Book are confirmed, the relevance of the SKA has increased with time. ALMA surveys have demonstrated that the planet formation region in disks (within 10-20AU from the star) are optically thick at millimetre wavelengths, requiring to extend observations to longer (SKA) wavelengths to probe the assembly of planets and reveal the mass budget of solids during planet formation. In this talk I will discuss the work done as part of the cradle of life working group starting from VLA and ALMA surveys of planet forming disks to prepare for SKA observations. I will also highlight the work that we are undertaking in the coming years to sharpen the plans for the SKA in this scientific area.

Reasearch area:

Cradle of Life

Parallel - Our Galaxy & Cradle of Life / 187

The importance of feedback and magnetic fields from diffuse medium to dense cores and protostellar jets in our Galaxy: radio continuum and synchrotron emission in the SKA era

Authors: Alessio Traficante[None]; Marco Padovani[1]

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

The massive star formation process involves various scales, spanning from giant molecular clouds, parsec-scales structures, down to the innermost regions of the star-forming cores. To fully understand the whole process, it is essential to analyse key interstellar medium properties, such as the interplay between gravity, turbulence, and magnetic fields, along with the impact of feedback from young high-mass star-forming regions. Recently, large-scale surveys using telescopes such as Herschel, APEX, and ALMA enabled the investigation of the role of gravity and turbulence from tens of parsec down to thousands of AU scales. Two critical aspects remain unexplored: 1) a comprehensive understanding of feedback at different scales and 2) the role of magnetic fields in star-forming regions.

Both feedback and magnetic fields can be investigated through radio emission observations in massive regions in the most unbiased way across the various environments in the Galaxy. A first Galactic Plane survey in L-band with MeerKAT has been recently performed, and a first pilot survey of a portion of the Galactic Plane at 3GHz, using MeerKAT(+), is underway to further demonstrate their potential as SKA precursors. A future Galactic Plane survey carried out with SKA at ~15 GHz aims to supplement these ancillary data, providing for the first time enough spectral coverage on a large portion of the Galaxy. This comprehensive approach will enable the first complete census of HII regions. Using specifically developed theoretical models, we will be able to shed light on the pristine phases of star-forming regions, quantify the energetics released as feedback onto natal clumps, and make clear the role of magnetic fields in the dynamical evolution.

Reasearch area:

Our Galaxy

Parallel - Our Galaxy & Cradle of Life / 49

Detecting magnetic fields in exoplanets through Auroral Radio Emission

Author: Corrado Trigilio[1]

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The detection of magnetic fields in exoplanets gives the possibility of investigating an important condition for the development of life on alien worlds. Magnetospheres act as shields preventing the arrival of ionised and potentially dangerous particles at the surface of the planets. On the other hand, the intense magnetic activity of parent stars could have influenced the atmospheric composition, in an early phase. Both planetary magnetospheres and stellar activity play important roles in creating a good environment for the development of life.
The detection of planetary magnetic fields is quite challenging. One possibility to infer it is through

radio observations. In fact, the interaction between the central star and the planet can trigger Auroral Radio Emission (ARE). The interaction can be due to the stellar wind impacting the planet's magnetosphere or to the planet crossing the stellar magnetosphere. In both cases the emission is due to Electron Cyclotron Maser Emission (ECME), respectively above the magnetic pole of the planet or of the star. SKA-LOW or SKA-MID are the most promising telescopes of the next decades.
We will discuss how ARE can give indications on planetary magnetic fields, together with preliminary results.

Reasearch area:

Cradle of Life

Parallel - Transients, Pulsars, GW / 50

Charting New Frontiers: Italian Efforts in FRB Multi-wavelength Studies and the CHORD Experiment

Author: Matteo Trudu[1]

Co-authors: Andrea Possenti [2]; Maura Pilia [2]

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One of the most intriguing problems in modern time-domain radio astronomy, which will be a key scientific question to address for the SKA observatory, is understanding the nature and origin of fast radio bursts (FRBs). FRBs are bright radio transients primarily originating from sources outside our galaxy, and, to date, they have only been observed in the radio band.
On April 28, 2020, the CHIME and STARE2 experiments detected two radio bursts closely resembling those produced by FRBs. These bursts were attributed to the Galactic magnetar SGR J1935+2164 and were simultaneously detected in the high-energy band. This event has positioned magnetars as one of the most plausible sources of FRBs, at least for a subset of them. It has also motivated multi-wavelength campaigns aimed at FRB-known sources to search for their high-energy and possibly optical counterparts.

In this presentation, I will discuss the efforts of the Italian research community from 2020 to the present day, focusing on several multi-frequency campaigns targeting FRB sources. Additionally, I will talk about INAF's involvement in the upcoming Canadian Hydrogen Observatory and Radio-transient Detector (CHORD), an innovative development from the SKA pathfinder CHIME. With its large field of view and real-time capabilities for detecting and precisely localising these events, CHORD has the potential to be a game-changer in the quest to achieve a long-sought panchromatic detection of FRBs.

Reasearch area:

Transients

Plenary - The SKA Observatory and the Italian involvement / 80

SKA Precursors: The Italian participation to MeerKAT and MeerKAT+

Parallel - EoR, Cosmology / 172

Prospects for physical cosmology in the SKA era

Author: Matteo Viel[1]

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

I will review the main scientific questions that can be addressed by SKA in terms of fundamental physics. I will focus on intensity mapping in the post-reionization era and address: nature of dark matter, dynamics and geometry of the Universe, neutrino masses. I will try to provide also some context and detail how and why probing high-z structure formation processes can be relevant, also with respect to other probes.

Reasearch area:

Epoch of Reionization

Parallel - Transients, Pulsars, GW / 148

Discussion

Parallel - EoR, Cosmology / 150

Discussion: Galaxy synergy with SKA EoR

Parallel - Transients, Pulsars, GW / 154

Discussion

Parallel - EoR, Cosmology / 156

Discussion

Parallel - Galaxy Clusters & Magnetism / 174

Discussion

Parallel - Our Galaxy & Cradle of Life / 176

Discussion

Parallel - Our Galaxy & Cradle of Life / 179

Discussion

Parallel - Our Galaxy & Cradle of Life / 181

Discussion