# Timetable

CT: Contributed Talk, KL: Keynote Lecture, IT: Invited Talk.

## Tuesday, 10 September 2024

| | | | |
|---|---|---|---|
| 10:00–11:00 | **Registration** | | |
| 11:00–11:10 | **Welcome remarks** | | |
| 11:10-11:40 | KL | **Simon Berry**<br>SKAO | SKA Project Update |
| 11:40-12:10 | KL | **Anna Bonaldi**<br>SKAO | Science with the SKA Observatory |
| 12:10-13:10 | **Lunch** | | |
| | **EoR & Cosmology** | | |
| 13:10-13:40 | IT | **Sambit Kumar Giri**<br>Stockholm University | Probing the Epoch of Reionization using the Square Kilometre Array |
| 13:40-14:00 | CT | **Ivelin Georgiev**<br>Stockholm University | Constraining cosmic reionisation by combining the kinetic Sunyaev-Zel'dovich effect and the 21 cm signal |
| 14:00-14:20 | CT | **Roman Pasechnik**<br>University of Lund | Signatures of supercooled cosmological phase transitions at NANOGrav, SKA and LIGO |
| 14:20–14:40 | **Coffee/Break** | | |
| | **High redshift universe & distant galaxies** | | |
| 14:40–15:10 | IT | **Anne Hutter**<br>Cosmic Dawn Center, University of Copenhagen | Unravelling the cosmic reionisation puzzle: 21cm signal - galaxy synergies |
| 15:10–15:30 | CT | **Alexandra Le Reste**<br>University of Minnesota | Revealing the neutral gas properties of analogs to the first galaxies: a challenge for SKA and pathfinders |
| 15:30–15:50 | **Coffee/Break** | | |
| | **Nearby galaxies and their environments** | | |
| 15:50-16:10 | CT | **Nushkia Chamba**<br>Stockholm University/NASA Ames Research Center | Linking stars, gas and the galactic environment using deep optical and HI surveys |
| 16:10-16:30 | CT | **Vicente Horacio Salinas Froemel**<br>Chalmers University | Exploring the neutral gas of galaxies in the Antlia cluster with MeerKAT |
| 16:30-16:50 | CT | **Clara Cabanillas de la Casa**<br>Instituto de Astrofísica de Andalucía | CO in the Hydra cluster |
| 16:50–17:30 | **Demos & Discussion (TBD)** | | |
| 18:00-19:00 | **Socializing at Wijkanders Restaurant** | | |
| 19:00-end | **Conference Dinner at Wijkanders Restaurant** | | |

## Wednesday, 11 September 2024

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|---|---|---|---|
| 8:45–9:00 | **Coffee** | | |
| | **Radio stars and stellar evolution** | | |
| 9:00-9:30 | IT | **Joe Callingham**<br>ASTRON / Leiden University | Radio stars and exoplanets |
| 9:30-9:50 | CT | **Santiago Del Palacio**<br>Chalmers University | Radio emission from stellar bowshocks in massive runaway stars |
| 9:50-10:10 | CT | **Behzad Bojnordi Arbab**<br>Chalmers University | Exploring the structure of evolved stars' extended atmospheres: SKA capabilities and observation opportunities |
| 10:10–10:25 | **Coffee/Break** | | |
| | **Magnetic fields** | | |
| 10:25-10:55 | IT | **Georgia Panopoulou**<br>Chalmers University | Galactic magnetism in 3D |
| 10:55–11:15 | CT | **Sara Piras**<br>Chalmers University | LOFAR Deep Fields: Probing the sub-mJy regime of polarized extragalactic sources in ELAIS-N1 |
| 11:15–11:30 | **Coffee/Break** | | |
| | **Technical paths toward the SKA** | | |
| 11:30–12:00 | IT | **Catarina Sahlberg**<br>Big Science Sweden | Industrial return from large-scale research facilities |
| 12:00–12:20 | CT | **Johan Wettergren**<br>Qamcom | Mechanical Industrialization of SKA RXPU |
| 12:20–12:50 | IT | **Bradley Frank**<br>UK Astronomy Technology Centre | Lessons Learned from South Africa's ProtoSRC |
| 12:50–13:50 | **Lunch** | | |
| | **SKA Very Long Baseline Interferometry** | | |
| 13:50–14:10 | IT | **Jack Radcliffe**<br>University of Manchester / University of Pretoria | The next-generation of VLBI surveys with the SKAO |
| 14:20-14:40 | CT | **Rubinur Khatun**<br>University of Oslo | Searching for dual AGN in galaxies using multi-wavelength observations |
| 14:40-15:00 | CT | **Jun Yang**<br>Chalmers University | Exploring the innermost thermal outflows in nearby AGNs with the SKA |
| 15:00–15:20 | CT | **Anne-Kathrin Baczko**<br>Chalmers University | AGN jets from mpc to Mpc |
| 15:20–15:40 | **Coffee/Break** | | |
| 15:40–17:00 | **Demos & Discussion (TBD)** | | |

# List of Abstracts – Talks

## Tuesday 10th

### SKAO Project Update

***Simon Berry*** KL

SKA Observatory

Construction of the SKAO's telescopes is moving at pace, with the first on-sky measurements emerging from SKA-Low in Australia and soon, completion of the first array releases for both Low and Mid telescopes and a ramp-up in effort towards first science to the community in due course.

I will provide an update on status of construction and the organisation and the efforts underway to grow the international partnership. I will reflect on Sweden's already significant role through our cooperation agreement with Chalmers and look forward to the steps needed for Sweden to complete the process for full Membership of SKAO, hopefully in the coming months.

### Science with the SKA Observatory

***Anna Bonaldi*** KL

SKA Observatory

The SKA Observatory will be very versatile and able to address an impressive breath of science. As a result, our science community is organised in several science working groups (SWGs). I will give an overview of all existing SWGs and the main questions they plan to address with SKA observations. I will also discuss the update to the SKA science book that is currently ongoing, and how to get involved in that and other SWG-led activities. I will discuss data access and proposal types, and the timeline to science operations. Finally, I will present the current SKAO-led science preparatory activities, such as the Science Data Challenges.

## Probing the Epoch of Reionization using the Square Kilometre Array

***Sambit Kumar Giri*** **IS**

Stockholm University, Sweden

The epoch of reionization marks the emergence of the first galaxies, which emitted energetic light into the intergalactic medium (IGM), leading to its ionisation and heating. The 21-cm signal produced by neutral hydrogen in the IGM serves as a unique probe of these early light sources, enabling us to measure their impact on the surrounding gas. This signal not only enhances our understanding of the IGM's evolution but also sheds light on the sources influencing this evolution. Current radio telescopes, such as the Low-Frequency Array (LOFAR), Murchison Widefield Array (MWA), and Hydrogen Epoch of Reionization Array (HERA), are working towards statistically detecting this signal. In the near future, the Square Kilometre Array (SKA) will begin observations and will be powerful enough to not only detect this signal but also produce images of the sky. In this talk, I will review the current progress in detecting the 21-cm signal during reionization and the insights gained about this period. Additionally, I will discuss the capabilities of the SKA in exploring both the astrophysics of reionization and cosmology.

## Constraining cosmic reionisation by combining the kinetic Sunyaev-Zel'dovich effect and the 21 cm signal

***Ivelin Georgiev**[*], **Adelie Gorce, Garrelt Mellema*** **CT**

[*]Stockholm University, Sweden

During the Epoch of Reionisation (EoR), the ultraviolet radiation from the first stars and galaxies ionised the neutral hydrogen of the intergalactic medium, which itself can emit radiation through the 21 cm hyperfine transition. Due to this, the 21 cm signal is a direct probe of the first stars in the early Universe and a key science goal for the future Square Kilometre Array (SKA). However, observing and interpreting this signal is a notoriously difficult task.

Another high-potential probe is the patchy kinetic Sunyaev-Zel'dovich effect (pkSZ). Induced by the scattering of Cosmic Microwave Background (CMB) photons with a medium of free electrons produced during the EoR, the effect altered the small-scale CMB temperature anisotropies, imprinting information on the growth of ionising bubbles during the EoR. While measurements of the pkSZ angular power spectrum by Reichardt et al. (2021) have reported a $3\sigma$ constraint of $D^{pkSZ}_{l=3000} = 3.0 \pm 1.0 \mu\text{K}^2$, the results are also subject to modelling uncertainties.

We propose an effective parametric model that establishes a connection between the 21 cm and pkSZ power spectra. Using this model to jointly fit mock 21 cm and pkSZ data points, we confirm that these two observables exhibit complementary characteristics, leading to significantly improved constraints on reionisation compared to analysing each data set separately. Our findings demonstrate that a few well-informed low-redshift (eg., z<8) measurements of the 21 cm power spectrum at $k \approx 0.1$ cMpc$^{-1}$ and the pkSZ power spectrum can precisely determine the reionisation history of the Universe.

## Signatures of supercooled cosmological phase transitions at NANOGrav, SKA & LIGO

***Roman Pasechnik*** **CT**

University of Lund, Sweden

Evidence for a stochastic gravitational wave background from pulsar timing arrays shows a strong potential for exploring new physics phenomena beyond the Standard Model, which has so far escaped detection at particle colliders. This presentation elucidates how gravitational waves measurements can deepen our understanding of particle interactions and violent processes in the very early Universe. The focus is on the NANOGrav, SKA and LIGO-Virgo-Kagra facilities, targeting conformal U(1) gauge extensions of the SM featuring very strong first-order phase transitions as an important and theoretically motivated case study. We examine how the existing and future data may constrain these models.

## Unravelling the cosmic reionisation puzzle: 21cm signal - galaxy synergies

***Anne Hutter*** **IS**

Cosmic Dawn Center, Niels Bohr Institute, University of Copenhagen, Denmark

The radiation emitted by the first galaxies in our Universe ionised the hydrogen in the intergalactic medium (IGM) during the first billion years, ushering in the Epoch of Reionisation. How did this last major phase transition that governed the evolution of the galaxies we see today happen? Was it driven by the few bright or numerous faint galaxies? Current and upcoming optical, near-infrared and radio surveys, with e.g. the Roman Space Telescope and the Square Kilometre Array, will tackle these questions: 21cm emission maps will trace the evolving distribution of ionised regions, while galaxy surveys will sketch the ionising sources and their distribution. Most importantly, combining these maps of the ionising sources and the ionisation topology opens up the possibility of constraining the ionising properties of the galaxies that are too faint to be observed.

Various works have explored the benefits of synergising surveys of the 21cm signal and emission line galaxies (e.g. Lyman-alpha emitters), finding that the corresponding cross-correlation functions and power spectra trace the overall ionisation state of the IGM. In this talk, I will provide an overview of these works and discuss the characteristic signatures of 21cm-galaxy cross-correlations, explaining how they trace the ionisation history and morphology and which type of 21cm and galaxy surveys can constrain these reionisation scenario characteristics.

## Revealing the neutral gas properties of analogs to the first galaxies: a challenge for SKA and pathfinders

***Alexandra Le Reste*** **CT**

University of Minnesota, United States

In the past years, the James Web Space (JWST) telescope has reshaped significantly our compre- hension of the first billion years following the Big Bang. To the surprise of the community, JWST is unveiling a greater abundance of galaxies, in more advanced stages of evolution than predicted by current galaxy models. These new observations are improving our understanding of the Epoch of Reionization, a pivotal cosmological era when the first galaxies ionized the intergalactic medium at z > 6, setting the stage for subsequent galaxy evolution. However, the physical conditions of the early universe prevent direct measurements of the fraction of ionizing photons escaping from the first galaxies, thereby hindering a comprehensive picture of the Epoch of Reionization to emerge.

To overcome the observational challenges encountered in the Early Universe, the community has been compiling and studying samples of local galaxies that serve as analogs to the galaxies respon- sible for Reionization at high redshift. These efforts have culminated in a characterization of galaxy properties linked to the emission of ionizing photons. Here, I will present the most recent results on the neutral gas properties of high-redshift analogs, and discuss what they reveal about the mechanisms facilitating the escape of ionizing radiation from galaxies. Furthermore, I will outline how deep, high-angular resolution observations of the 21cm line, obtained through the Square Kilometer Array (SKA) and its pathfinders, will be instrumental in fully revealing the processes driving the emission and escape of ionizing radiation from galaxies.

## Linking stars, gas and the galactic environment using deep optical and HI surveys

***Nushkia Chamba***, Alejandro Borlaff, The LSST Dark Energy Science Collaboration, Matthew Hayes, Pamela Marcum* **CT**

*Stockholm University, Sweden/NASA Ames Research Center, United States

Mapping stars and gas in nearby galaxies is fundamental for understanding their growth and environment. However, many studies do not account for the faint outskirts of these galaxies. We demonstrate this issue by discussing the concept of size and ‘stellar edges’, defined as the outermost location where in situ star formation significantly drops in galaxies. We compare this definition with the gaseous distribution in galaxies, traced using the hydrogen 21-cm line (HI). By combining deep imaging from the VLT Survey Telescope and MeerKAT, we show that the stellar and HI distribution of galaxies in the Fornax Cluster are up to fifty percent more truncated compared to isolated galaxies, demonstrating the dramatic impact of the environment on size evolution. Our results highlight the importance of coordinating efforts with the SKA, LSST and Euclid for characterizing low surface brightness emission in galaxies.

## Exploring the neutral gas of galaxies in the Antlia cluster with MeerKAT

***Vicente Horacio Salinas Froemel, Kelley M. Hess*** **CT**

Chalmers University of Technology, Sweden

Neutral atomic hydrogen (HI) provides the gas reservoir that fuels star formation. Environmental mechanisms in galaxy clusters alter the fate of this gas, impacting the evolution of galaxies. These range from gravitational to hydrodynamical effects, which might in turn ignite or boost internal processes such as AGN and gravitational instabilities. MeerKAT HI and radio continuum data of the nearby Antlia cluster (d = 38 Mpc) offers the opportunity to explore in detail the distribution of the neutral atomic gas in and around galaxies. Furthermore, the unrelaxed nature of Antlia, and its connection to the Hydra cluster via a filamentary structure to the north presents unique circumstances to study galaxy evolution in the early stages of cluster formation. One remarkable example is the Seyfert II galaxy NGC3281, located at the north east part of Antlia, notable by its active nuclei and strong HI absorption. In this preliminary study, we look in detail at the HI emission and absorption of NGC3281 and its surroundings, in order to uncover its possible formation history, and provide insight about how the AGN present at the center of the galaxy may have been triggered and is interacting with its surrounding environment. Future studies will involve a detailed analysis on all the HI sources in Antlia as a whole to better characterize the different evolutionary mechanisms in the cluster's galaxies.

## CO in the Hydra cluster

***Clara Cabanillas de la Casa**, Kelley M. Hess, Lourdes Verdes-Montenegro* **CT**

*Instituto de Astrofísica de Andalucía, Spain

Cold molecular gas is the penultimate gas phase in the baryonic cycle leading to star formation, and a key regulator of galaxy growth. Traced by the CO line, it is a most sensitive tracker of galaxy interactions with their environment. However, there is not a consensus on how environmental mechanisms, such as ram pressure or tidal interactions, affect the reservoirs traced by CO. To date, it is unclear if cluster galaxies are CO deficient, or if these processes can trigger CO and star formation. The Hydra I galaxy cluster is at a remarkable intermediate stage of assembly, manifesting both virialized and recently adhered structures, and active processes of ram pressure. Thus, it offers a rich yet unexplored niche for molecular gas studies. We present the combination of ALMA ACA CO(1-0) observations of 108 galaxies with a spatial resolution of 10" (2.8 kpc) with well matched MeerKAT HI observations (11x1800; 3.1x5.1 kpc) of this cluster. This allows us to offer an unprecedented comparison of atomic and molecular gas morphologies over similar spatial scales in Hydra's galaxies. We present preliminary results of our census of molecular gas in Hydra Cluster, comparing the relative cold gas fractions as a function of stellar mass and location within the cluster. At the dawn of the SKA, this work uniting MeerKAT and ALMA shows the impact that the next generations of radio telescopes will have in the field of galaxy evolution.

## Radio stars and exoplanets

***Joe Callingham*** **IS**

ASTRON, Netherlands / Leiden University, Netherlands

One key question that astronomy is attempting to answer is whether there are habitable planets around stars other than our Sun. While we have entered an era where identifying nearby exoplanets has become standard, discerning whether the environmental conditions dictated by the host stars are suitable for life has proved far more elusive. The detection of low-frequency radio emission from an M dwarf or an exoplanet provides a direct probe of extrasolar space weather and the planet's magnetic field - information crucial for assessing the potential habitability of the planet. In this talk, I will outline our LOFAR survey of stellar systems, with a focus on our recent detection of strong, highly circularly polarised low-frequency radio emission associated with nearby stars - the expected signpost of star-exoplanet interactions. I will discuss how our survey represents the most comprehensive observations of stellar systems at low frequencies, and the implications of this new population in understanding the magnetosphere of M dwarfs and exoplanetary magnetic fields. I will conclude with our progress in determining the expected periodicity of the radio emission from star-planet interactions.

## Radio emission from stellar bowshocks in massive runaway stars

***Santiago Del Palacio*** **CT**

Chalmers University of Technology, Sweden

Massive stars launch hypersonic winds that generate strong shocks in the interstellar medium. In the case of runaway stars with supersonic peculiar velocities, the resulting shock structure forms a distinctive bow shape, known as a bowshock. Within these shocks, the material heats up and compresses, producing free-free radiation, while also relativistic particles are accelerated, leading to synchrotron radiation. I will present an overview of the observational status of stellar bow shocks in radio so far, theoretical predictions of their emission, and future prospects for studying these radio sources with the SKA.

## Exploring the structure of evolved stars' extended atmospheres: SKA capabilities and observation opportunities

***Behzad Bojnordi Arbab**, **Wouter Vlemmings**, **Theo Khouri**, **Suanne Höfner*** **CT**

*Chalmers University of Technology, Sweden

The heavy mass-loss experienced by evolved asymptotic giant branch (AGB) stars provides metals and dust to the interstellar medium (ISM). In our current understanding, mass loss occurs through dust-driven winds originating from the extended atmospheres of these stars. State-of-the-art simula- tions show that large convective cells play an important role, but recent observations at milliarcsecond resolution with ALMA have shown that the conditions in the extended atmospheres might be different than predicted by the models.

Low-frequency observations of evolved stars with the Square Kilometer Array (SKA) and the next- generation Very Large Array (ngVLA) will make it possible to study the critical outer regions of the extended atmospheres where dust forms and is accelerated in a novel way. With the high resolution and sensitivity of upcoming observatories such as SKA, we can use the continuum emission to constrain atmospheric density and temperature structures at larger distances from the star. Also, simultaneous observations of SKA, ngVLA, and ALMA will produce wide-range multi-wavelength data for various radii of the extended atmosphere, enabling us to test and constrain theoretical models in a way that was not possible before. With the large field of view of SKA, we can further study the temporal evolution of evolved star atmospheres and dust-forming regions.

In this presentation, I will discuss the observable features of the upcoming SKA observatory, the unique opportunities for SKA to image AGB stars, and how multiwavelength observations from SKA and ALMA can enhance the detailed study of evolved stars' atmospheres.

## Galactic magnetism in 3D

***Georgia Panopoulou*** **IS**

Chalmers University of Technology, Sweden

The Galactic magnetic field is one of the least understood components of the ISM. It influences processes over a large range of scales, from star-formation to the diffusion of cosmic rays within the Galaxy. However, the effects of the magnetic field remain poorly understood, in part due to difficulties in measuring its properties over a large enough dynamic range in scale. With the advent of Gaia, a new era for magnetic field studies has begun. We can now probe the magnetic field properties in 3D, using stellar polarimetry and Gaia distances. I will describe recent progress on mapping the magnetic field with this technique, leading to new insights on the magnetized ISM in the Solar neighborhood. I will discuss prospects for synergy between this tomographic mapping with the many probes of the magnetized ISM from the SKA.

## LOFAR Deep Fields: Probing the sub-mJy regime of polarized extragalactic sources in ELAIS-N1

***Sara Piras*** **CT**

Chalmers University of Technology, Sweden

Quantifying the number density and physical characteristics of extragalactic polarized sources is crucial for future Faraday Rotation Measure studies to probe Galactic and intergalactic magnetic fields. We present a polarimetric study at 114.9–177.4 MHz of the ELAIS-N1 LOFAR deep field. An area of 25 deg2 was imaged at 6”-resolution in the Stokes Q,U parameters. A 1$\sigma$ sensitivity of 19 $\mu$Jy/beam was reached in the central region by aligning the polarization angles and stacking datasets from 19 eight-hour-long epochs taken in two different observing cycles.

The depolarization level of sources known to be polarized at 1.4 GHz was quantified. Twenty-five polarized sources were detected above 8$\sigma$, five of which had not been detected in polarization at any other radio frequencies before. Seven additional polarized components were found by lowering the threshold to 6$\sigma$ at positions corresponding to sources known to be polarized at 1.4 GHz. In two radio galaxies, polarization was detected from both radio lobes, so the final number of associated radio continuum sources is 31. The detected sources are weakly polarized, with a median degree of polarization of 1.75%. The sources previously detected in polarization at 1.4 GHz are significantly depolarized at 150 MHz. The catalog is used to derive the polarized source counts at 150 MHz. This is the deepest and highest-resolution polarization study at 150 MHz to date. A full characterization of the sources and an analysis of the catalog will be presented.

## Industrial return from large-scale research facilities

***Catarina Sahlberg*** **IS**

Big Science Sweden, Sweden

Big Science Sweden (BiSS) has a government assignment to strengthen the opportunities of Swedish companies, universities and institutes to deliver components and services to thirteen large-scale international research facilities. The focus of our support is high-tech deliveries that, in addition to the business opportunity, contribute to strengthened research environments in Sweden, that drive innovation and that expand international collaborations. Currently, hundreds of companies are active members of the BiSS network. BiSS also works to ensure that more people from Sweden discover career opportunities at the Big Science facilities through outreach activities aimed mainly at students.

Over the last few years, BiSS has actively worked to support Swedish deliveries to SKAO. Thanks to leading Swedish research and long-term industrial collaborations at Chalmers and Onsala Space Observatory, Sweden has been exceptionally successful in this regard. Sweden is estimated to receive an industrial return from SKAO of at least EUR 31 million, which far exceeds the guaranteed return.

In this talk, I will describe how BiSS works to support Swedish universities, institutes and com- panies to contribute to large-scale research facilities in general, and SKAO in particular.

## Mechanical Industrialization of SKA RXPU

***Johan Wettergren*** **CT**

Qamcom, Sweden

The receiver pedestal unit (RXPU) for the Square Kilometre Array (SKA) has the function of packetizing the sampled date from the receivers. It contains an FPGA with high frequency clocks and large power consumption. The mechanical compartmentalizing of the RXPU should address interfaces, practical handling, transportation, cooling and electromagnetic compatibility (EMC).

A driving aspect in the industrialization is the number of units to be delivered. For SKA it is neither just a few pieces, nor mass production of thousands of pieces. Instead, the number of deliveries is around 150. This means that it is definitely worthwhile to adjust the design to contain as simple parts as possible which have a sensible means of mounting. On the other hand, optimization must stop at a reasonable level, since it would cost more than it saves to perfect the design.

The EMC radiated emissions of the RXPU were measured for the pre-industrialized design with the proper lids both put on and taken off. The conclusion was drawn that the airflow honeycomb vents could be machined directly in the box, that the finger gaskets could be removed and that the number of lid screws could be reduced. Also, the FPGA heatsink and airflow were analyzed, which led to using a reduced weight heatsink based on an off-the-shelf product.

Finally, the parts of the RXPU were reworked to facilitate more generous manufacturing tolerances, sturdier design and simpler assembly.

## Lessons Learned from South Africa's ProtoSRC

***Bradley Frank*** **IS**

UK Astronomy Technology Centre, United Kingdom

The Square Kilometre Array Regional Centres (SRCs) will provide a crucial link between the SKA and the scientific community. They will host a diversity of services and activities, ranging from large scale computing to data- and labour-intensive analyses. These activities, and thus the effective design and operation of the SRCs and the SRC Network, will form an essential part of the scientific lifecycle. In simple terms, science with the SKA will be impossible without an effective network of SRCs. We've faced a very similar challenge with MeerKAT and the Inter-University Institute for Data Intensive Astronomy (IDIA). Our challenges and experiences with the design, development and op- eration of Ilifu (in response to the community's diverse and demanding requirements) provided an effective testbed to prototype ideas and approaches which could be scaled up for the SKA and SRCs. That's why we were proud and confident in claiming the title of the premier proto-SRC. In my talk, I'll cover the evolution of Ilifu. I'll provide a retrospective view of the highlights and challenges we experienced along the way – from the tremendous success in facilitating hundreds of papers and dozens of science cases, to the technical and leadership "opportunities" involved in operating such a facility. I'll confront several paradoxes that we faced during our journey towards MeerKAT science, and will outline a few lessons learned and approaches for the future.

## The next-generation of VLBI surveys with the SKAO

***Jack Radcliffe*** **IS**

University of Manchester, United Kingdom / University of Pretoria, South Africa

In the past few decades, radio surveys have provided us with unique insights into many areas of astrophysics, such as star formation, supernovae, active galactic nuclei, pulsars, cosmology and much more. A vital aspect of these surveys is the Very Long Baseline Interferometry (VLBI) technique, which can provide some of the highest resolutions possible in astronomy. This method has made crucial discoveries in many areas of astrophysics and geodesy, including cosmology, galaxy formation and evolution, the innermost regions of active galactic nuclei, explosive phenomena and transients, stars and stellar masers in the Milky Way, celestial reference frames and space applications.

In this talk, I will introduce new science and technical developments in VLBI and focus on the Square Kilometre Array and its role in the next generation of VLBI surveys. I will also highlight the exciting prospects for VLBI with other instruments, such as the ngVLA and the next-generation Event Horizon Telescope.

## Searching for dual AGN in galaxies using multi-wavelength observations

***Rubinur Khatun*** **CT**

University of Oslo, Norway

Supermassive black hole (SMBH) binaries form due to galaxy mergers. The final coalesce of such SMBH pairs are the sources of gravitational waves. When the SMBHs are accreting, they form pair of AGN which are known as dual or binary AGN. A large sample of AGN pairs at different separations can help us to understand the SMBH growth as well as the evolution of galaxies. However the number of such dual/binary AGN with separation ¡ 10 kpc is still limited. We have searched for such binary/dual AGN in a sample galaxies using multi-band sub-arcsec observations. In this presentation, I will discuss these results in the context of recent advancements (Gaia, Euclid) and highlight the significance of the SKA in this area.

## Exploring the innermost thermal outflows in nearby AGNs with the SKA

***Jun Yang*** **CT**

Chalmers University of Technology, Sweden

Optical observations of active galactic nuclei (AGNs) often reveal kpc-scale [O III] outflows that align with radio jet directions. These outflows, particularly in the inner nuclear regions, might have relatively high temperatures and powers, produce detectable free-free emissions and form non-thermal shocks in complex nuclear regions. The nearby dwarf galaxy NGC 4395 hosts an AGN with an extremely low mass ( 10000 solar masses) black hole. In the inner pc-scale region, we have identified a non-thermal shock region, likely resulting from a collimated outflow with thermal (free-free) continuum emission. This is probably the only known source displaying such a relatively hot and powerful outflow to date. The upcoming powerful SKA-Mid would allow us to accurately image these pc-scale thermal outflows, study outflow astrophysics and probe AGN feedback.

## AGN jets from mpc to Mpc

***Anne-Kathrin Baczko*** **CT**

Chalmers University of Technology, Sweden

The process of jet formation and collimation in Active Galactic Nuclei (AGN) as well as their interaction with the host galaxy are still key open problems despite decades of astrophysical studies. While cm- and mm-VLBI studies have made progress in understanding jet collimation in strongly Doppler-boosted one-sided jets, the symmetry of these systems and the interplay with the properties of the host galaxy are still poorly understood. On the other hand, AGN feedback and black hole feeding can be probed with sub-arcsecond resolution, e.g., with the International LOFAR Telescope, eMERLIN, and Jansky-VLA.

To improve our understanding of jetted AGN, we need to connect these two scales from mpc to Mpc. This is challenging with current instruments, but has good prospects with future advances represented especially by the SKA and the ngVLA. In this talk I will present first results of combining these different scales to follow the evolution of jets from formation to dissipation in a pilot study of misaligned jets combining HSA, EVN+eMERLIN, and LOFAR. Special emphasis will be placed on the LINER NGC 3894, which shows a change in its jet position angle of at least 40 degrees.

To overcome the problem of the low number statistics of VLBI studies of double-sided jets required for symmetry studies, I will present possible solutions using clustering algorithms on large radio astronomical datasets such as the LOFAR Two-metre Sky Survey. These will form an ideal test bed to study jet evolution from MHz to tens of GHz with the SKA.

**CT**