CONTACT

THE SKAO'S MAGAZINE

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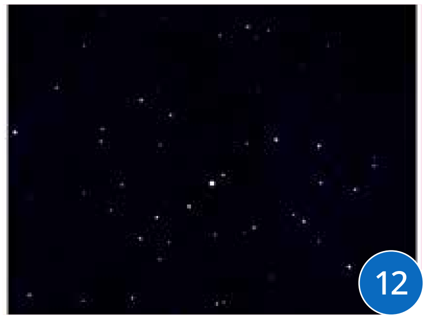
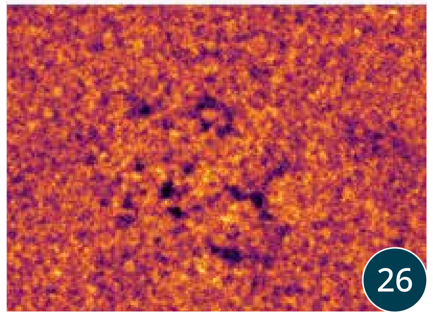




Another "big lift" of an SKA-Mid dish – read more on page 8.

Welcome to the seventeenth edition of the SKAO magazine, *Contact*. This issue of *Contact* is one of superlatives: "largest ever", "deepest ever", "first", "astonished", and quite rightly so. In the previous issue, you will have seen mention of the first interferometric fringes from two stations of the SKA-Low telescope.

In this edition you will, most pleasingly, read about the SKA Observatory's very first image. It was constructed with data from four stations of SKA-Low in Western Australia. With less than 0.8% of the planned array it is, necessarily, a primitive image. Nevertheless, it is a wonderful achievement, demonstrating that the SKAO's system and software is working. This is a result only possible through the efforts of too many people to count, and I thank them all. We will only grow from here and I look forward to SKA-Low improving rapidly and dramatically, and the first similar image from SKA-Mid in due course.

It is good to see some of our industrial and research partners celebrated in this issue. You can read about the groundbreaking work Italy's Elemaster Group has done in the development of the digital processing system for SKA-Low – already being used in the production of the first image. In Canada, the NRC's Herzberg Astronomy and Astrophysics Research Centre is supplying hundreds of cryogenically cooled low noise amplifiers (LNAs) for use in the SKA-Mid Band 2 receivers. These are exceptional LNAs designed to allow SKA-Mid to achieve ultra-low noise as we aim to detect the incredibly weak signals from the cosmos.

There are several excellent stories on the science being delivered by the SKAO's precursor and pathfinder telescopes, with new results from MeerKAT, GMRT, Apertif on Westerbork, and ASKAP being discussed. We also welcome a new pathfinder to the SKAO family: Tianlai, a hydrogen intensity mapping experiment located in north-west China.

We also say ***au revoir*** to the long-time Chair of the SKAO Council Dr Catherine Cesarsky, who concluded eight remarkable years of service at the helm of Council on 3 February 2025. For me, working alongside Catherine was an absolute pleasure and I took so much from her wisdom, advice and support. Please read the article – her journey through science and life is an inspiration.

I also give my sincere thanks to Daan du Toit of the Department of Science, Technology and Innovation in South Africa, who has served in a truly exemplary role as vice-chair with Catherine throughout. Daan will not be leaving us, he will revert to being the lead South African delegate on Council.

Catherine's successor is Dr Filippo Zerbi, lately science director at INAF, Italy. Filippo has already chaired his first Council meeting and I am excited to be working with him and also with the new Vice-Chair, Inmaculada Figuero Rojas of Spain.

There are numerous other articles in this edition of *Contact*; so please pull up a chair, with a beverage of your choice, and enjoy this issue. Please join me in congratulating the global SKAO team for all they contribute to the project.

PROF. PHILIP DIAMOND, CBE
SKAO DIRECTOR-GENERAL


Nineteen students took part in the free camp, hearing from leading experts in STEM fields. Credit: ICRAR

STEM camp takes students 'out of this world'

BY GINA PEARSE (SKAO)

For the second year in a row, the SKAO partnered with the International Centre for Radio Astronomy Research (ICRAR) to deliver the popular Stargirls+ STEM camp in Australia's Mid West.

The immersive hands-on experience was attended by 19 regional students, with several students travelling up to nine hours to join the camp.

Stargirls+ was open to Year 8-12 (ages 12-18) girls and gender minorities interested in pursuing a career in astronomy, engineering or data science. The free two-day camp was an opportunity to practise real-world astronomy research skills and hear from leading experts in the field.

The camp was hosted at the Geraldton Universities Centre and delivered by the ICRAR Education and Outreach team, with financial and in-kind support from the SKAO team in Australia.

SKA-Low Commissioning Scientist Dr Shivani Bhandari said the collaboration reflected a shared commitment to fostering diversity and encouraging young individuals to explore STEM fields.

"As a young person living regionally, you might love science, technology or engineering, but not necessarily know what options are available to you," Dr Bhandari said.

"I'm excited to share my passion and provide guidance to those interested in science and astronomy."

Dr Bhandari was joined by two of her SKA-Low colleagues to participate in "speed networking" with the students.

Angela Teale spoke with the students about her non-traditional pathway to her role as SKA-Low's head of engineering operations. She encouraged students to "follow their smile" when pursuing their career pathway.

The sessions also included representatives from SKAO collaborators ICRAR, AusSRC and CSIRO, and a nighttime "sidewalk astronomy" event.

Students' feedback showed how much they valued the experience:

- "[I enjoyed] seeing the real-life research and projects that are discovering new things and meeting with the women who are involved in them and getting to ask them questions."
- "All people were very kind and made sure all the girls knew what they were doing at their pace. It was more casual, making it more comfortable for me to be there."

SKAO and ICRAR look to continue to offer local students this unique opportunity in the future.

New Canadian initiative to develop next generation of scientific leaders

BY NRC HERZBERG ASTRONOMY AND ASTROPHYSICS RESEARCH CENTRE

The National Research Council of Canada (NRC) has begun an innovative new programme to foster inclusive research using SKAO data and develop future scientific leaders with a foundation in community support and engagement.

The Canadian SKA Scientist Programme will fund top-level postdoctoral researchers at Canadian universities to pursue their own cutting-edge, independent research focused on SKAO science goals, using data from SKA precursors and pathfinders including the Canadian CHIME telescope. The selected scientists will also be tasked with supporting the Canadian astronomical community to take full advantage of access to the SKA telescopes and their data. The first cohort is expected to start in late 2025 and will begin the formation of a network of SKA experts across Canada.

"The Canadian SKA Scientist Programme aims to help superb young scientists make their own exciting discoveries and ensure that Canadian researchers have effective and equitable access to the full potential of the SKA telescopes," explains Michael Rupen, NRC's SKA Programme Lead. "The Programme will also ensure that future scientific leaders have a solid foundation in community support and engagement."

For more than three decades, Canadian astronomers have been at the forefront of defining the fundamental science and necessary technologies for the SKA project, and today the country is supplying key technological components, including the SKA-Mid telescope's correlator and low-noise amplifiers. Canada will also host the only SKA Regional Centre in the Americas, an important node in the international SKA Regional Centre Network which will provide astronomers with access to science-ready data products.

French-language podcast *Radio Cosmos* launches

BY TANYA PETERSEN (SKACH)

The SKA Switzerland Consortium (SKACH) has launched a new podcast series that takes listeners on an exciting journey to the far reaches of the Universe, exploring some of the most fundamental scientific questions of our time.

In addition to looking out into the Universe, the French-language *Radio Cosmos* is also a deep dive into the latest technology developments on Earth, investigating how the SKA telescopes, artificial intelligence and supercomputing will revolutionise astronomy.

The first season contains four episodes – *Listening to the Universe, Aliens and Exoplanets, Supermassive Black Holes, and Dark and Quiet Skies*. Hosted by SKACH astrophysicist Dr Mark Sargent and computer science master's student Alexandra Lagutova, the programmes feature experts around the globe talking about the next frontiers in radio astronomy.

With financial support from the SKAO, the IAU Office for Astronomy Outreach, the Swiss Society of Astrophysics and Astronomy and the Municipality of Bern, SKACH produced the series to make radio astronomy accessible to a wide general audience.

French, German and Italian are three of the official languages of Switzerland and SKACH hopes to produce German and Italian (and perhaps English!) versions of the podcasts in the future.

French speakers (and learners) can tune into the podcasts on:

- Spotify
- Apple
- Podcast Addict

Radio Cosmos is also available on the SKACH website where listeners can also explore additional links to the topics discussed in the episodes.

Credit: SKAO/Max Alexander

UN exhibition highlights Indigenous views of the night sky

BY MATHIEU ISIDRO (SKAO)

In November a photographic exhibition supported by the SKAO went on display at the United Nations Headquarters in New York, featuring for the first time the Indigenous communities that have traditionally lived on the lands on which the SKAO facilities are being built.

The exhibition, *Our Fragile Space*, highlights the importance of space sustainability in the context of growing amounts of space debris, and the impact of satellite constellations on the night sky and astronomy.

Renowned photographer Max Alexander travelled the world last year to capture the perspectives of Indigenous communities on the night sky as part of a new chapter for the exhibition.

With support from the SKAO and our collaboration partners SARAO and CSIRO, he travelled to the SKA telescope sites in South Africa and Australia in August 2024 to meet members of the San and Wajarri communities respectively. The photographs are a powerful reminder of both communities' ancestral ties to the night sky, and how a rapidly changing sky might be affecting their heritage.

It is believed to be the first time that the two communities have had visibility in a photographic exhibition at the United Nations.

The exhibition has already travelled extensively. Armed with its powerful new chapter, it is expected to continue its international tour, with several dates lined up, starting with the World Trade Center in New York next month.

Top left: *Preserving knowledge, Northen Cape, South Africa*

Oom ("Uncle") Raymond, Tannie ("Auntie") Anna and Oom James are descendants of South Africa's First Nations Peoples present in the Northern Cape for thousands of years: the San and Khoekhoe. To this day, the majority of the population in the small town of Carnarvon has Indigenous heritage. The three community leaders lament the fact that traditional knowledge of the night sky is being lost as younger generations seek work opportunities in the cities.

Top right: *Painting Culture, Mullewa, Western Australia*

Susan Merry is a Wajarri Elder and artist based in the Mid West region of Western Australia. Wajarri People place great importance on expressing their connection to the sky, water, and land through art. Here Susan is seen using traditional dot-painting and symbols to represent families camping on Wajarri Country by the Murchison river, with the Emu in the Sky and Seven Sisters above, a common occurrence in Susan's childhood.

ngVLA progresses with prototype construction

BY MATTHEW TAYLOR (SKAO)

The US National Radio Astronomy Observatory (NRAO) has celebrated the lifting of its first Next Generation Very Large Array (ngVLA) prototype dish onto its pedestal. The ngVLA will be complementary to the SKAO's own telescopes, covering frequencies at the high end of, and above, those observed by SKA-Mid.

The original VLA is an SKA pathfinder, and the new prototype is the first dish constructed at the site in New Mexico for around 25 years.

"We're very, very pleased – this was a milestone for us," said NRAO Director Prof. Tony Beasley during a visit to SKAO Global HQ in the UK, where he updated staff on the latest progress.

"We'll be building 244 antennas as part of ngVLA. We've been very fortunate that the National Science Foundation has funded us to do the basic development work and to build this prototype antenna."

Engineering tests on the dish will be followed in a few months' time by scientific testing, scheduled to take six to 12 months.

"There are plans to build another prototype, possibly in Green Bank, and there are a couple of adjacent projects that are interested in building some of these antennas. So it represented the start of several efforts," Prof. Beasley said.

In 2023, the joint SKA-ngVLA science meeting in Vancouver focused on how the telescopes would complement each other, something Prof. Beasley also highlighted during his visit.

"The ngVLA sits in the [frequency] region between ALMA and the SKA telescopes. A lot of the science cases we're interested in are anywhere between five and 120 Ghz. Together all of these instruments present an arsenal of astronomical tools that can be used to look at different problems."

The first ngVLA prototype dish on site in New Mexico, USA. Credit: NSF/AUI/NRAO

SKA-Mid construction update

BY TRACY CHEETHAM, SKA-MID SITE CONSTRUCTION DIRECTOR

It was another perfect blue sky that greeted us on 26 February, as we prepared for the "big lift" of the second SKA-Mid dish. After anxiously waiting for the wind to settle, the main reflector and its back-up structure were safely hoisted atop the pedestal, an operation that takes around an hour.

This second big lift was swiftly followed by a third only a few weeks later, on 17 March, and the lifting of the pedestal for our fourth dish! This great progress reflects a combined effort of our SKAO, SARAO, CETC54 and Power Adenco colleagues.

These milestones bring us to within touching distance of the first stage of telescope delivery, the four-dish array known as AA0.5.

In addition to progress on the main dish structures, all the key components that will transform the AA0.5 dishes into functioning radio antennas – such as the receivers, cryostats to keep the receivers cool and digitisers which convert analogue signals captured by the dish – have now been manufactured.

'First fringes' on the horizon

The objective of AA0.5 is to demonstrate the earliest working version of the telescope, to verify that the system is working as planned in a realistic operating environment, including subsystems like the control and data processing software. From there, we will maintain a continuously working and expanding facility.

After each big lift comes commissioning and verification, a thorough and methodical process to test the dish.

This work continues for the first SKA-Mid dish, to assess things like the accuracy of its tracking and requirements such as surface accuracy. When those tests are complete, the dish Assembly, Integration and Verification (AIV) team takes over to install the remaining hardware including the receivers and digitisers, so that the dish structure can be tested as a whole. It's at that point that the verified dish system will be "plugged in" to the backend systems, including the correlator.

The first three dish structures are due to be handed over to the system AIV team later in the year, which means there's another exciting milestone now on the horizon. Interferometry – where the signals from each dish will be combined – is expected to commence in the last quarter of 2025. This is what astronomers refer to as "first fringes".

Preparations for AA0.5 are also ramping up in Cape Town at the System Integration Test Facility (SITF), where a representative signal chain, which simulates the operation of four dishes, is now operating. The team will continue to work on adding more functionalities and reliability so that everything is ready when the real dishes come online.

Maser time

May 2025 will see the arrival on site of a hydrogen maser, being supplied by the Swiss division of the multinational Safran, which will ultimately be used in conjunction with the two existing MeerKAT masers to form the heart of the SKA timescale. Hydrogen masers provide an extremely high level of timing accuracy, needed to combine data from all the antennas so that they can work together as a single telescope. It's also essential for timing pulsars, one of the key science interests for the SKAO.

A piled antenna foundation in the telescope's core. Credit: SKAO/Bruce Boyd

Solar power progress

The SKAO team has been testing the first containerised remote solar power station prototype, a scaled-down version of what is planned for future deployment to power the more distant antennas on SKA-Mid's spiral arms, where it is neither practical nor cost-effective to run power cabling.

The prototype is expected to be installed on site in July, where the team will test whether the design meets the stringent requirements for electromagnetic shielding, needed to protect the telescope's sensitive equipment and observations, while also ensuring that the power supply meets our quality needs.

This work is also aimed at reducing the risk for future independent power providers, who do not usually face such strict requirements on electromagnetic interference. The SKAO will provide a reference design to assist local providers when bidding for future contracts.

Infrastructure beyond AA0.5

On the infrastructure front, there's been more impressive progress from the team, as we continue to prepare roads, power and fibre in readiness for future stages of telescope deployment. To date, all the foundations, power and fibre for the AA1 stage of delivery (eight dishes) have been completed, as well as 64% of the new roads required in the core area, along with more than half of those needed on the telescope's Brandvlei spiral arm. Almost half of the steel overhead powerlines and 60% of the poles for fibre-optic cables, required to connect SKA-Mid's dishes, have been installed.

Health, safety and environment

Health and safety is a crucial part of the successful delivery and operation of SKA-Mid and we are proud that a safety culture is being fully embraced by staff and contractors on site. Our annual HSE awards at the end of 2024 not only recognised construction workers and contractor staff who have excelled in this area, but also featured toolbox talks on topics relevant to the challenges faced on site.

This year our contractors will be implementing wellness programmes and HSE reward schemes, and there will be monthly training sessions with contractor safety teams and construction supervisors. The SKA-Mid Health and Safety team will also begin a mentorship programme for contractor safety officers.

Heritage and environmental walkthroughs continue, to identify protected flora and fauna and determine whether species need to be protected or relocated, or whether

Above: The "big lift" of the second SKA-Mid dish main reflector onto the pedestal on 26 February 2025.

infrastructure must be rerouted. Twenty-nine protected plant species were successfully translocated in 2024 and their health and wellbeing are being monitored. Government inspections at the end of 2024 demonstrated that we have achieved 94% environmental compliance and 100% water licencing compliance.

Local community participation

We continue to benefit greatly from local community contributions to our workforce. More than 300 local community members are employed on site by Power Adenco and CETC54 from the local towns of Carnarvon, VanWyksvlei, Williston and Brandvlei, with 58% aged between 18 and 35 years old.

There are also 12 small, medium and micro enterprises (SMMEs) from the four towns which have been appointed by Power Adenco for various infrastructure work packages to date, together employing 38 people from the local communities. Outside of construction hours, the SMMEs are attending a six-month training programme through Power Adenco which focuses on managing human resources, regulatory compliance, accounting, on-site coaching and mentoring, tendering and site/contractual administration, skills which will continue to be valuable outside of the SKA project.

Video spotlight: Hear from members of the local community who are part of the team at the SKA-Mid site.

SKA-Low construction update

BY ANT SCHINCKEL, SKA-LOW SITE CONSTRUCTION DIRECTOR

This month we celebrate one year since the first SKA-Low antenna was assembled and installed at Inyarrimanha Ilgari Bundara, the CSIRO Murchison Radio-astronomy Observatory, and reflect on the work that has occurred both on and off the site of the SKA-Low telescope in the previous 12 months.

Central and Remote Processing Facilities

Since our last update several exciting milestones have been reached across the SKA-Low site. The final two Remote Processing Facilities (RPFs) were delivered this month, meaning all 18 of these facilities are now in place to (in the next several years) receive the signals from the far-flung stations along SKA-Low's spiral arms. These digital signals will then be sent on to the Central Processing Facility (CPF), which is now well into construction. This month we excitedly installed the first six modules of this large facility. In total 21 modules, each more than twice the size of a shipping container, will make up the CPF. This shielded facility, custom-designed by Aurecon and fabricated by Ventia and its subcontractors, will contain 180 racks that will house a wide range of processing and support equipment for SKA-Low.

In addition to the signals from the RPFs, the CPF will also receive data directly from the nearby antenna stations in the telescope's core. The installation of the optical fibre cables that will feed this data through to the specialised digital signal processing systems was recently completed within the core, and the project to bring these 65,000 fibres to the CPF location is well underway. This represents over 35% of power and fibre installed across the entire site.

SKA-Low Field Technician Emily Goddard works on antennas. Credit: SKAO/Max Alexander

As the core progresses, on a particularly hot summer's day, it could be mistaken for a mirage of an oasis. More than half of the steel mesh that creates a consistent base for the antennas has been placed, and when viewed from afar resemble large pools of silvery water. Around half of the telescope's total stations, made up of more than 65,000 antennas, will eventually be located here.

Antenna deployment

As of 7 March 2025 it has been a year since the first of SKA-Low's eventual 131,072 antennas were assembled and installed. Since then an additional 2,000 antennas have been built and placed across the southern spiral arm of the array. This first completely populated cluster, made up of six stations each with 256 antennas, is truly a sight to behold. While only one of these stations is currently part of our operating array, over the next 12 months it will be joined by the other five stations in this cluster. This will involve not only the installation of SMARTBoxes, optical fibre and power cabling and Field Node Distribution Hubs, but also the verification and integration of these systems into the array.

March also marks a year since our first cohort of SKA-Low field technicians joined us. Last December several of these field technicians received their Open Cabling License, after months of hard work and studying at the Technical and Further Education (TAFE) centre in Geraldton. We recently expanded the team with seven new field technicians who joined us in February, as our antenna deployment ramps up with increased antenna deliveries from Sirio Antenne in Italy, and we bring more stations into the array.

Safety and sustainability

The health and safety of our people, and the protection of the environment on which we work, is crucial to the successful delivery and operation of SKA-Low. We are proud of the culture that is being cultivated and embraced by both staff and contractors on site.

A key issue is prevention – this is always best in the safety domain. We strongly encourage hazard identification to reduce the risks of exposure to harmful situations. In summer, when temperatures were over 46°C, we held a campaign to reduce heat exposure through scheduling, as well as encouraging buddy systems to ensure we are checking in on the hydration and health status of others.

A focus on site continues to be emergency response. Given the remote location of the SKA-Low telescope, it is vital that we can respond quickly in the event of an emergency. The Health, Safety and Environment team, alongside the Ventia and Cape teams and on-site paramedics, continue to provide both medical and emergency response training to staff and contractors.

Above: The delivery of the first CPF modules to the site of the SKA-Low telescope.

Medical drills have been conducted, providing different teams with the opportunity to learn the skills needed to extract a patient in the event of an emergency.

Sustainability initiatives continue across the SKA-Low site. Single-use plastic water bottles are no longer available. Contractors and employees are now required to reuse and refill multi-use drink containers. Similarly, single-use coffee cups will soon be phased out. Instead, contractors and employees will be encouraged to use "keep cups". These initiatives are an important move towards plastic waste reduction. You can read more about the SKAO's sustainability initiatives on page 50.

Education on the protection of the environment on which the SKA-Low telescope is located also continues. The Health, Safety and Environment team provide regular information on how to protect native fauna and flora, as well as how to identify and appropriately dispose of invasive species.

AA0.5

Following exciting announcements last year that the first image had been produced from one station, and "first fringes" with two stations, the SKA-Low telescope has now achieved its next milestone – correlation between the first four stations. This has been the work of multiple teams, from the assembly and installation of the 1,024 antennas that make up these four stations, to the verification and integration of these antennas into the entire system, to the computing and software that is needed to get these data to our commissioning scientists. You can read more about this work on page 12.

'Tip of the iceberg' – the journey to produce SKA-Low's first test image

BY SEBASTIAN NEUWEILER (SKAO)

On the right is an unassuming image. At its centre is a small, glowing dot. It is surrounded by several smaller spots resembling flecks of paint. If a picture is worth a thousand words, then this image hints at the unravelling of cosmic secrets. Each dot is a radio galaxy, typically billions of light years from us, emitting radio waves only detectable by the most sensitive radio telescopes.

This image was produced by an early working version of the SKAO's Australian-based telescope, SKA-Low. Specifically, it used the data collected from four connected stations – each made up of 256 two-metre-tall metal antennas – installed over the past year at Inyarrimanha Ilgari Bundara, the CSIRO Murchison Radio-astronomy Observatory.

How this image came to be, much like the image itself, is not as simple as it first appears.

In the heart of Western Australia's outback, where the characteristic red soil of Wajarri Yamaji Country stretches up to the wide horizon, one of the world's largest radio telescopes is taking shape. Over several months in 2024, through both dry heat and heavy rain, the first 1,024 antennas of the SKA-Low telescope were placed across its southern spiral arm. They are grouped evenly within expansive silver circles of steel mesh, referred to as stations, which provide the antennas with a consistent base.

Black tendrils spread out across the ground mesh like veins. These cables connect the antennas to 24 small, yet heavy, aluminium chassis' that each house sensitive electronics inside. Known as SMARTBoxes, they convert signals received through the antennas from electrical to optical to avoid generating unwanted emissions and to improve the transmission of the signals over long distances.

The cables converge at the edge of the station where they feed into the Field Node Distribution Hub (FNDH) – a kind of two-way street for fibre-optic and coaxial cables. The FNDH distributes power to the station, while routing the optical signals towards on-site processing facilities, where they can be turned back to electrical and digitised.

After being digitised the signals are routed 700 km away into a station beamformer – "beamforming" being the technique SKA-Low uses to digitally point at different parts of the sky – at the Pawsey Supercomputing Research Centre in Perth. It is here that the signals from the first four stations were combined to produce the image on the opposite page.

"It is a uniquely complex system, like a living organism," said Lucio Tirone, SKA-Low Assembly, Integration and Verification (AIV) Lead Engineer, who oversees the team responsible for ensuring this system works.

"Making sure the SKA-Low telescope works requires making sure all the individual components that make it up work as intended," he said.

"Each part is carefully verified at the factory where the supplier builds it. Then it's transported to the site and is tested again in its operational environment. This is called product-level AIV. Then we have a system-level AIV, where we check that everything works together and collaborates correctly.

"This happens for each of the components of the telescope – hardware, software, firmware – everything that is a component that makes up the big system."

Left: The S8 cluster as seen from above, which includes two of the stations used to create the first image.

The first image from an early working version of the SKA-Low telescope, produced using data collected from the first four connected SKA-Low stations, which together comprise 1,024 of the eventual 131,072 antennas, spread over a distance of just under 6 km.

The image shows around 85 galaxies in an area of the sky of about 25 square degrees – approximately equivalent to 100 full Moons. The dots in the image look like stars but are in fact some of the brightest galaxies in the Universe, seen in radio light.

This data was obtained at Inyarrimanha Ilgari Bundara, the CSIRO Murchison Radio-astronomy Observatory. The SKAO and CSIRO acknowledge the Wajarri Yamaji as the Traditional Owners and Native Title Holders of the observatory site.

Elsewhere in Australia, teams of software and firmware engineers have been preparing the parts of that big system that are needed to process the data captured by the antennas. Within Pawsey are a correlator, tied-array-level beamformer, and pulsar search and timing engines. The tied-array beamformers produce extremely sensitive beams by adding station beams together, which can be pointed anywhere within the station beam field of view. The correlator multiplies station beams together to produce visibilities, which lead to the production of sky images.

The Perentie team at CSIRO, Australia's national science agency, is made up of system, network, firmware, software and hardware engineers, and is building the correlator and tied-array beamformers for the SKA-Low telescope.

After successfully developing a prototype system integration facility in Sydney to test equipment destined for SKA-Low, as well as production systems in the Integration and Test Facility in Geraldton, the team installed hardware for the correlator and beamformer in Pawsey, ready to be integrated with the first four SKA-Low stations.

CSIRO Perentie Team Lead Grant Hampson said the team demonstrated an integrated software deployment from the highest levels to the lowest levels controlling the correlator and beamformer.

"The Perentie team has also developed a world-first real-time high-speed integrated test environment for in-system testing for the SKA telescope and other astronomy instruments," he said.

At the same time, TOPIC, another team of test engineers and software integrators in the Netherlands, worked to install and connect this hardware into the rack at Pawsey. They then collaborated with a third team of integrators at the SKAO and CSIRO, called Vulcan, to deploy the

Simulating SKA-Low's future observations: (Top row) By 2026/2027, with more than 17,000 antennas, SKA-Low will be able to detect over 4,500 galaxies in the same patch of sky as its first image. With over 78,000 antennas by 2028/2029, it will be able to detect more than 23,000 galaxies in the same area.

(Bottom row) From 2030, with its full 131,072 antennas spread over 74 km, around 43,000 galaxies will be revealed, while deep surveys will be able to detect a dazzling 600,000 galaxies in the same area of sky.

integrated SKA-Low software system. The final step was to achieve real data flow, ensuring the system is set up and connected correctly.

Back on site the "beating heart" of the SKA-Low telescope, a rubidium clock, now had a pulse. Part of the synchronisation and timing system, it provides reference signals essential for ensuring all components of the signal chain are synchronised with nanosecond precision.

This system enabled the integration of the first SKA-Low station, and from there, testing of the telescope as a scientific instrument began.

"The final user of the system is a worldwide community of radio astronomers," said Tirone.

"We need to be sure that the telescope allows them to do the right science, and so now our commissioning scientists will undertake a series of tests aimed at proving that the science data acquired meets what the SKA-Low telescope is poised to deliver."

In mid-2024, at the Science Operations Centre in Perth, the SKA-Low Science Commissioning team celebrated as the first tests came in: they were encouraging. The first station was performing well. Just weeks later, a second station was integrated into the array.

By September, after having resolved one-by-one the various glitches that arose in the early days of telescope operations, a significant milestone was reached – the successful correlation of data from separate antenna stations.

The SKAO's telescopes are radio interferometers. They work by combining data from stations spread over large distances to create virtual telescopes equivalent in size to the separation between the furthest antennas. As more stations are added into the array, the scientific power of the SKA-Low scales, enabling a deeper look in the Universe and the production of images of higher and higher quality.

"A radio telescope doesn't just snap a photo like your phone camera," said SKA-Low Commissioning Scientist Dr Shivani Bhandari.

"Each antenna captures the radio waves from a piece of the sky. We then have amazing supercomputers that stitch all that information together with some mathematical magic in a process called Fourier transform."

By the end of 2024 another two stations had joined the array. Progress, however, did not come easily.

"We had to proceed very carefully to make our current progress with calibrating the array and then to be able to produce images, because four stations is the bare minimum required for this kind of data processing," Dr Bhandari says.

"Our testing has been complicated because we continue to find and address system glitches which naturally arise in these early days of telescope operations.

"Despite these challenges, it has been amazing to work through the stages of a system where the high level of top-notch planning, engineering and construction is plainly evident."

In early 2025 the team recorded the first correlated visibilities between all four stations. The data quality was extraordinary. Over several weeks they worked on calibrating the array and imaging with the four stations.

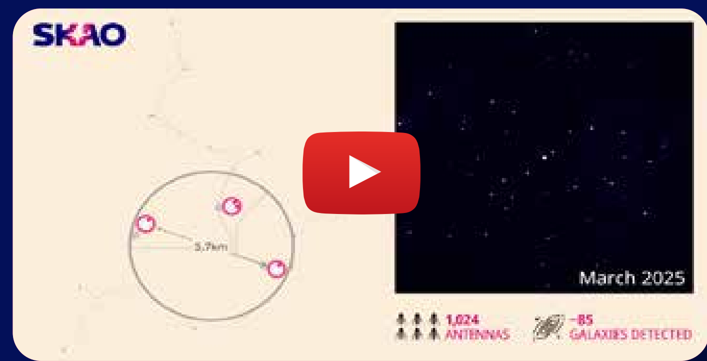
After many hours of refinement came success.

The first image shows 85 of the brightest known galaxies in the region, all containing supermassive black holes. At its centre is PKS 0521-36, one of only a handful of radio galaxies that are known to possess jets visible in both radio and optical portions of the spectrum. The team calculates that when the telescope is complete, it will be sensitive enough to reveal more than 600,000 galaxies in the same frame when undertaking a deep survey campaign.

"This image has been made with less than 1% of the SKA-Low telescope, and already we see some amazing objects," Dr Bhandari says.

"This is just the tip of the iceberg. With the full telescope we will have the sensitivity and resolution to reveal the faintest and most distant galaxies.

"But this image doesn't just give a glimpse into what's next. It shows how far we have already come. The components of the telescope are working, the timing, control, processing and communication are right, the details of the system are understood at a high level, and we can calibrate the array. We are legitimately taking the first steps towards unlocking the science that is possible with this telescope."



Video spotlight: Animation showing the various stages of delivery of the SKA-Low telescope over the coming years, and the images it is expected to be able to produce of the same area of the sky

One of the SPS sub-racks during an EMC test in the anechoic chamber of the Eletech Lab. Credit: Elemaster Group

Elemaster and the challenge of detecting the faintest signals from the Universe

BY ELEONORA FERRONI AND DR JADER MONARI (INAF - ITALIAN NATIONAL INSTITUTE FOR ASTROPHYSICS)

Italy's Elemaster Group is developing a groundbreaking digital processing system for the SKA-Low telescope. This ambitious project will detect extremely faint cosmic signals with unprecedented precision, enabling a significant leap in our understanding of the Universe.

SKA-Low is often referred to as a software telescope, as its 131,072 antennas do not have moving parts. Instead, they will be digitally "steered" to observe different parts of the sky, relying on advanced software to make sense of billions of "streams" of data across 65,000 radio frequencies.

Elemaster and its partners, including collaborators in the UK, the Netherlands, France, China and Australia, are delivering the highly specialised signal processing subsystem (SPS) hardware for SKA-Low, which will handle that immense computing load.

The baseline designs for the system were developed by Italy's National Institute for Astrophysics (INAF), which collaborated with Italian electronics company Sanitas to build the first generation of the SPS system. Elemaster was awarded the €45m SKAO contract to industrialise the design and build digital, software-enabled circuitry to digitise, correlate, combine, and help interpret radio light before it is transported hundreds of kilometres for further processing.

"SKA-Low's signal processing system has extremely demanding requirements because of the huge number of antennas connected over distances of up to 74 km," said the SKAO's Jacque Stoddart, SKA-Low Digitisation Project Manager.

"As well as a very high-performance processing centre, the system's long-range connections need the capacity to accommodate an enormous volume of data captured by the antennas. It's a unique challenge and critical to enabling science with SKA-Low."

Elemaster, a leader in mechatronics since 1978, is taking on that challenge by leveraging the Eletech Innovation Design Centre at its Italian headquarters near Milan, contributing to the company's ability to manage complex projects in advanced electronics.

The centre can count on over 50 engineers and a laboratory for electromagnetic compatibility testing. It will perform hardware/software integration and compliance testing for the signal processing subsystem and continuing refinements to support SKA-Low's long-term operations, with three cabinets set up in the Italian facility (SKAO LAB) in the same way as they are in the Remote Processing Facilities on site in Australia, to enable realistic testing. The laboratory is accessible to the entire SKA project community and will also serve as a training facility once validation activities are completed.

"To ensure the accuracy of the analogue to digital conversion, we're sampling the incoming signal at an extremely high rate – 800 million times per second, across more than 262,000 channels – and each of those samples has to be precisely aligned in time so that the signals can be combined correctly. This is an enormous challenge," said Marco Arrigoni, Eletech SKA System engineering manager.

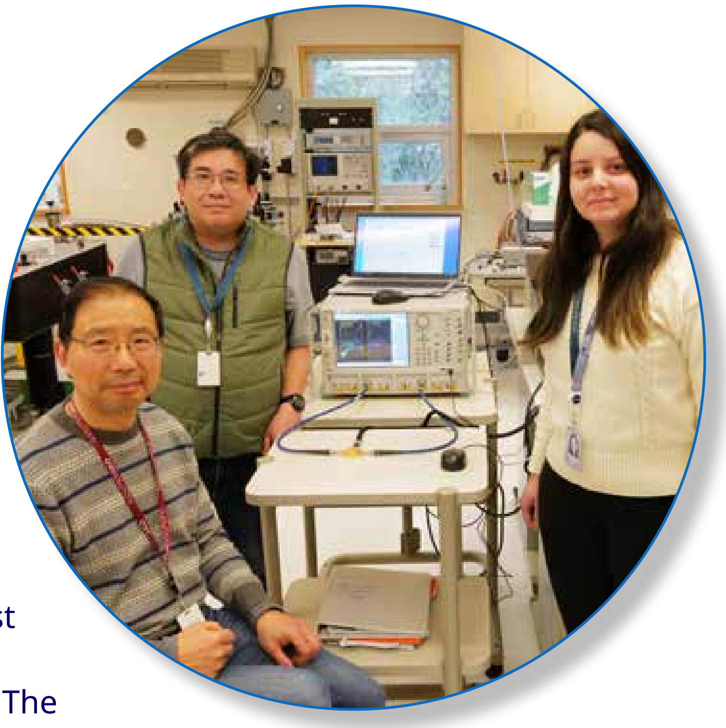
A variety of factors drive the technical challenges. Engineers must ensure the system has very low radio frequency emissions so as not to interfere with the telescopes' observations, and synchronisation signals must be tested using cutting-edge laboratory equipment. This is enabled using the SKAO LAB test laboratory, which utilises metrology-level reference clocks and simulates synchronisation signal transmissions as they would be on site. Collaboration with development groups across four continents and spanning seven time zones adds another layer of complexity to the process.

INAF has played a key role in developing the tile processing module (TPM), with Jader Monari (co-author of this piece) serving as the programme manager for Italy. Although it was developed for the SKA project, the TPM does not only benefit astronomical research. Currently in use at the Croce del Nord radio telescope and the European Space Surveillance and Tracking (EUSST) network, the TPM prototype has potential applications in various non-astronomical fields, from advanced radar systems to satellites and even medical devices like CT scanners and nuclear magnetic resonance imaging.

Above: One of the SPS cabinets at Elemaster's SKAO LAB in Osnago. Credit: Elemaster Group

First state-of-the-art cryogenic low-noise amplifiers arrive for SKA-Mid

BY NRC HERZBERG ASTRONOMY AND ASTROPHYSICS RESEARCH CENTRE



Astronomical signals received by the SKA antennas are extremely faint, meaning they must be highly amplified while limiting the amount of unwanted noise introduced by the system itself. The SKAO requires state-of-the-art low-noise amplifiers (LNAs) to perform this critical function.

The National Research Council of Canada (NRC) is Canada's representative in the SKAO. One part of its contribution to the project is supplying hundreds of cryogenic LNAs that will be integrated into the SKA-Mid array Band 2 receivers, with two LNAs fitted in each receiver.

"Our LNAs are known for their exceptional performance," says Adam Densmore, Team Leader of the Radio Instrumentation Team at the NRC's Herzberg Astronomy and Astrophysics Research Centre.

"We have demonstrated some of the lowest-noise amplifiers reported and we are constantly refining our designs and processes to meet the future demands of radio astronomy."

For the frequency range covered by Band 2, the sensitive radio receiver equipment must be kept exceptionally cold, as heat generated by electronics and from the environment adds "thermal noise" to the astronomical signals, drowning them out. The LNAs are housed inside the Band 2 receiver, which is cooled by a compressed helium system supplied by the UK's Oxford Cryosystems and South Africa's EMSS.

"In Band 2, each SKA-Mid dish must be able to pick up extremely faint signals that are over a million times weaker than what a typical mobile phone tower transmits," says Jayashree Roy, SKAO Signal Processing Engineer. "To achieve this, the dish system must keep its own noise as low as possible. A high-quality low-noise amplifier is crucial; without it, distant astronomical signals would be obscured in the background noise, making it difficult to extract any meaningful information," she adds.

An astronomical challenge

"The biggest challenge was to achieve ultra-low noise. The LNAs add less than 2 kelvin of noise across the entire operating band, which is a record low while maintaining high gain stability. This is critical for correct calibration of astronomical observations at cryogenic temperatures," explains Frank Jiang, a Senior Research Officer at the NRC who led the development of the LNAs.

The semiconductor chips in the NRC's LNAs are cryogenically cooled to just 15 kelvin (-258°C), which allows them to achieve the high gain and lowest noise performance. However, the extreme cold introduces other challenges.

"We try to use commercial components as much as possible, but they must be carefully chosen to ensure that they can withstand the extremely low operating temperature," explains Jiang. "We rigorously qualify each component in our cryogenic chamber before implementing them into our LNA designs."

Additionally, to ensure that the LNAs can be manufactured in high volumes while still meeting the performance and quality standards required, the team needed a design that was as tolerant as possible to the inherent fluctuations in the component characteristics at extremely low temperatures.

A combination of exceptional expertise and ultra-specialised facilities had the NRC well positioned to tackle the challenge of meeting the requirements of the LNAs for the SKA-Mid Band 2 receivers.

Above: NRC Herzberg Astronomy and Astrophysics Research Centre staff Dr Frank Jiang, Dominic Garcia and Dr Deisy Formiga Mamedes testing LNAs for SKA-Mid.

The NRC delivered the first batch of its LNAs to SKA-Mid in November 2024. To meet the SKAO's schedule, the team built the first 20 LNAs in-house at the Dominion Astrophysical Observatory in Victoria, Canada, and outsourced the remainder to Ontario-based Nanowave Technologies Inc. (Nanowave), which has already completed production of more than 60 additional LNAs passing all requirements.

Nanowave designs and manufactures radio frequency components and subsystems for the space, aerospace and defence industries and has a proven track record of delivering cryogenic LNAs for radio astronomy.

Working together since 1997, the NRC and Nanowave produced the cryogenic LNAs for the Atacama Large Millimeter/submillimeter Array (ALMA) in Chile, as well as for the SKA precursor MeerKAT radio telescope in South Africa. Working on these projects with the NRC helped Nanowave develop the expertise to successfully expand into new markets.

"Our collaboration is an excellent example of how NRC-developed technology enables Canadian companies to compete in markets where technological innovation and manufacturing expertise result in internationally competitive advantages," says Nanowave CEO Justin Miller.

Below: The first batch of SKA Band 2 LNAs made at NRC-HAA. 16 of 20 are shown. Credit: NRC

LNAs are essential components for both the SKA-Mid and SKA-Low telescopes. Alongside those being produced for SKA-Mid in South Africa by the NRC for the Band 2 receiver, Sweden's Low Noise Factory is producing LNAs for the Band 1 receiver. For SKA-Low, the UK company Kasdon Electronics (under subcontract from Italy's Sirio Antenne) is providing the LNAs which will enable the very faintest low-frequency signals to be amplified.

FEATURED IMAGE

Emu in the Sky, Wajarri Country, Western Australia

This stunning photograph was taken from Inyarrimanha Ilgari Bundara, the CSIRO Murchison Radio-astronomy Observatory on Wajarri Country, last September by renowned photographer Max Alexander. It forms part of his highly acclaimed exhibition *Our Fragile Space*. Supported by the SKAO, Alexander travelled to South Africa and Australia last year to meet the San and Wajarri communities respectively as part of an effort to record Indigenous Peoples' perspectives of the night sky around the world.

The Emu (Yalibirri) in the Sky is an important nighttime feature for the Wajarri Yamaji of Western Australia. Its position informs Wajarri People when it's time to hunt for emu eggs, when the Emu in the Sky faces down it's time to hunt. So-called "dark constellations" like the Emu are known to several Indigenous communities around the world. They use the contours of dust visible in the Milky Way from dark locations, rather than connecting stars.
Credit: Max Alexander

The most up-to-date visualisation of our galaxy based on data gathered by ESA's Gaia telescope. Credit: ESA/Gaia/DPAC, Stefan Payne-Wardenaar

Let's talk about... our galaxy

BY ANNE DANIELS (SKAO)

The European Space Agency's (ESA's) star-mapping space telescope Gaia is retiring after a mission of 10 years. With 1.8 billion stars in our galaxy accurately mapped in visible light, what remains to be discovered in the radio regime?

Gaia's legacy

ESA's Gaia satellite launched in 2013 and travelled to Sun-Earth Lagrange point L2, or about 1.5 million km away from Earth. From this famous vantage point, telescopes like the James Webb Space Telescope, Euclid and Gaia have an undisturbed view of the Universe. Gaia spent over a decade surveying our galaxy, mapping the location and movement of stars, discovering the Milky Way's galactic architecture along the way.

The Milky Way is a spiral galaxy, home to an estimated 100-400 million stars. The galactic disc measures 100,000 light years across – that means light needs 100,000 years to travel across it – and is 1,000 light years thick. With these galactic distances, no space telescope can travel beyond it, which means that there is no way to take a picture of our own galaxy in its entirety. As a "retirement gift" from Gaia, ESA released the most accurate and up-to-date model of the Milky Way; the closest we'll ever get to a galaxy selfie.

More Gaia measurements will be released in two more data releases, but, with the telescope retiring, does that mean we cannot learn anything more about our home galaxy?

Of course not! The Gaia telescope observed the galaxy in visible light, but interstellar dust and gas hinder these observations. That is why the SKA telescopes will also cast a glance into our cosmic backyard to reveal new details through radio observations.

A first glimpse into our galaxy's heart

Located at a distance of only about 26,000 light years – relatively nearby in astronomical terms – we find our nearest supermassive black hole. Sagittarius A* is a four million solar mass black hole and resides at the centre of our galaxy. Optical telescopes like Gaia are unable to peer into this region because interstellar dust blocks the light. That is why radio telescopes like the SKAO's are needed to study the galactic centre.

Dr Rainer Schödel is a member of the SKAO's Our Galaxy Science Working Group and head of the Galactic Centre Group at the Institute of Astrophysics of Andalusia (IAA-CSIC) in Spain.

In 2022 South Africa's MeerKAT radio telescope released the most sensitive radio image ever of the galactic centre, revealing many previously unknown features.

"It has been used for a significant number of research projects, from studying outflows of gas from the galactic centre to understanding its magnetic field. It showed in great clarity an outflow that must have originated in the region a few million years ago," adds Rainer.

The MeerKAT telescope consists of 64 dishes spread out over 8 km in the Karoo region in South Africa. The precursor telescope will become part of the SKA-Mid telescope, which will expand the array to 197 dishes spread out over around 150 km. More dishes mean we can see fainter objects, and longer baselines – the distance between dishes – give us more detail.

The interstellar medium – the gas and dust in galaxies – determines the structure and view of galaxies as seen here in Stephan's Quintet imaged by the James Webb Space Telescope. Credit: NASA, ESA, CSA, and STScI

He explains: "The centre of our galaxy is of enormous astrophysical interest because we can observe it at more than 100 times higher resolution than the nearest centre of a comparable galaxy, Andromeda [the nearest large spiral galaxy]."

"The inner ~500 light years around Sagittarius A* is our galaxy's most active star-forming region and its most extreme astrophysical environment. The galactic centre therefore serves as a fundamental laboratory for astrophysics and offers an enormous discovery potential."

"The fully developed SKA-Mid array will allow us unprecedented insight into the galactic centre, such as solving the 'missing pulsars' riddle," explains Rainer. "There should be far more pulsars in the galactic centre than we have seen so far."

Pulsars are spinning neutron stars that regularly cast a beam of light. By timing these with exceptional accuracy, radio telescopes can use pulsars as cosmic clocks. The galactic centre is the most extreme gravitational environment. So by studying changes in how the pulsar clocks "tick", Einstein's general theory of relativity can be tested in the most extreme environment possible.

Lives and deaths of stars

The MeerKAT image of the galactic centre also led to the discovery of many new supernova remnants, the final echoes of massive stars that ended their lives in gigantic explosions.

Dr Carla Buemi from the Italian National Institute for Astrophysics (INAF) explains: "Supernova remnants are the footprints of one of the most catastrophic events that can occur in the galaxy, and profoundly affect our galaxy's chemistry, dynamics and star formation. They originate from the compression of circumstellar material by the expanding shock generated from the stellar explosion and represent the last visible phase of a massive star."

Supernova remnants shine bright in radio light because the expanding shockwave accelerates electrons, causing them to spiral around magnetic field lines and emit a type of radiation called synchrotron radiation, which is bright in radio wavelengths.

Radio telescopes are not only great at spotting stars at the end of their lives, but also help shine a light on the formation and evolution of stars.

"Radio observations of our galaxy play a fundamental role in our understanding of stellar evolution, allowing us to explore the complex interaction between stars and their environments," says Carla.

"Radio waves are particularly useful because they can penetrate the obscuring matter along the line of sight, revealing hidden environments rich in dust and gas that surround stars during crucial stages of their life. These environments, such as the dense clouds where stars form, are typically along the galactic plane, making them strongly obscured at other wavelengths."

Carla and her team at the Catania Astrophysical Observatory often use the enormous database built by the Gaia telescope for their galactic research. The collection includes extremely accurate information on the locations, movements and distances of nearly two billion stars.

She explains: "Our research greatly benefits from the accuracy of the Gaia telescope's measurements. It allows us to know with great precision the distance to even very distant stars, and thus to derive parameters such as a star's intrinsic luminosity, age and mass, which are key parameters for comparison with the predictions of theoretical evolutionary models."

During their lifetime, massive stars enrich their environments with stellar material lost in winds or during supernova explosions at the end of their lives. This material eventually becomes part of the next generation of stars.

"By studying these and other phenomena at radio wavelengths, we gain insights into the complex interplay between stars and the interstellar medium and better understand how this cycle of matter drives the evolution of galaxies," adds Carla.

Prof. Naomi McClure-Griffiths

"What excites me most about the SKA telescopes is actually being able to do what we can do in the Milky Way now, in galaxies throughout the local Universe. That's a really big game changer."

"With the SKA telescopes, we expect to detect faint radio emissions that are below the detection thresholds of current instruments, revealing new populations of objects such as compact supernova remnants, evolved stars, and young planetary nebulae."

Interstellar investigations

The space between the stars is not empty; it contains interstellar dust and gas and gets enriched by stellar winds and supernova explosions. Dubbed the interstellar medium, it forms an interesting region to learn more about the process of star formation.

"If we want to understand the Universe, we want to understand how galaxies go from being bodies of gas to being star-forming entities," explains Prof. Naomi McClure-Griffiths, research expert on the interstellar medium and outgoing chair of the SKAO Science and Engineering Advisory Committee.

"We need to study the evolution of the interstellar medium; how it goes from being warm and diffuse and just sort of hanging around, to being a dense, cold blob that's self-gravitating and forms a star."

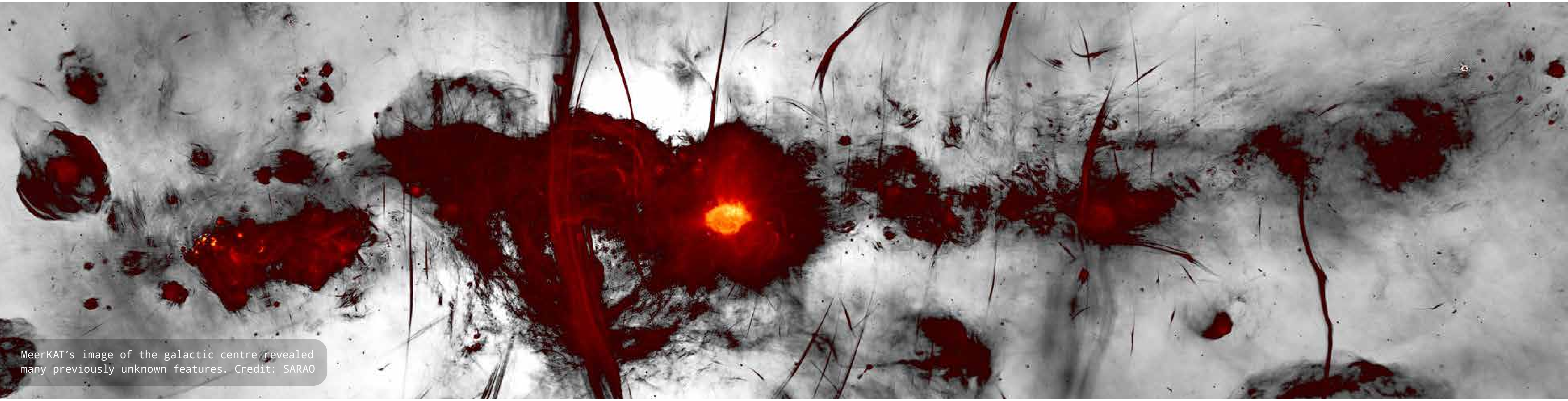
An important tracer for these studies is the 21 cm emission line from neutral hydrogen gas, which is abundant in the interstellar medium.

"I often think of atomic hydrogen as smoke particles in a room. If you open the door in a smoky room, you see the draft in the smoke particles' movement. The same thing is true with hydrogen gas in the galaxy. Anything that imparts movement in the galaxy, we see in the hydrogen gas. It's a wonderful tracer because it's not just two dimensional. It's a spectral line, so we get this third dimension, we get movement," adds Naomi.

The SKA telescopes will be the highest-resolution radio telescopes and will immensely improve studies of the interstellar medium using the famous 21 cm line.

"The SKAO is like finally getting glasses when you're struggling to see a whiteboard in your classroom. A lot of the physics that happens in the interstellar medium happens on very small scales. And for the most part we've not had the ability to see things on those scales. It's the scale at which gas clouds collide with each other and where thermal condensation trails the gas to cool down," explains Naomi.

"But what excites me most about the SKA telescopes is actually being able to do what we can do in the Milky Way now, in galaxies throughout the local Universe. That's a really big game changer."



MeerKAT's image of the galactic centre revealed many previously unknown features. Credit: SARAO

Latest SKAO Science Data Challenge supports community collaboration

BY JOSH RODDEN AND CASSANDRA CAVALLARO (SKAO)

What brings together 375 researchers from 55 teams across 18 countries? The answer is the SKAO's latest Science Data Challenge, one of a series designed to prepare the science and computing communities for dealing with SKAO data. This newest challenge also places a strong emphasis on knowledge sharing among teams.

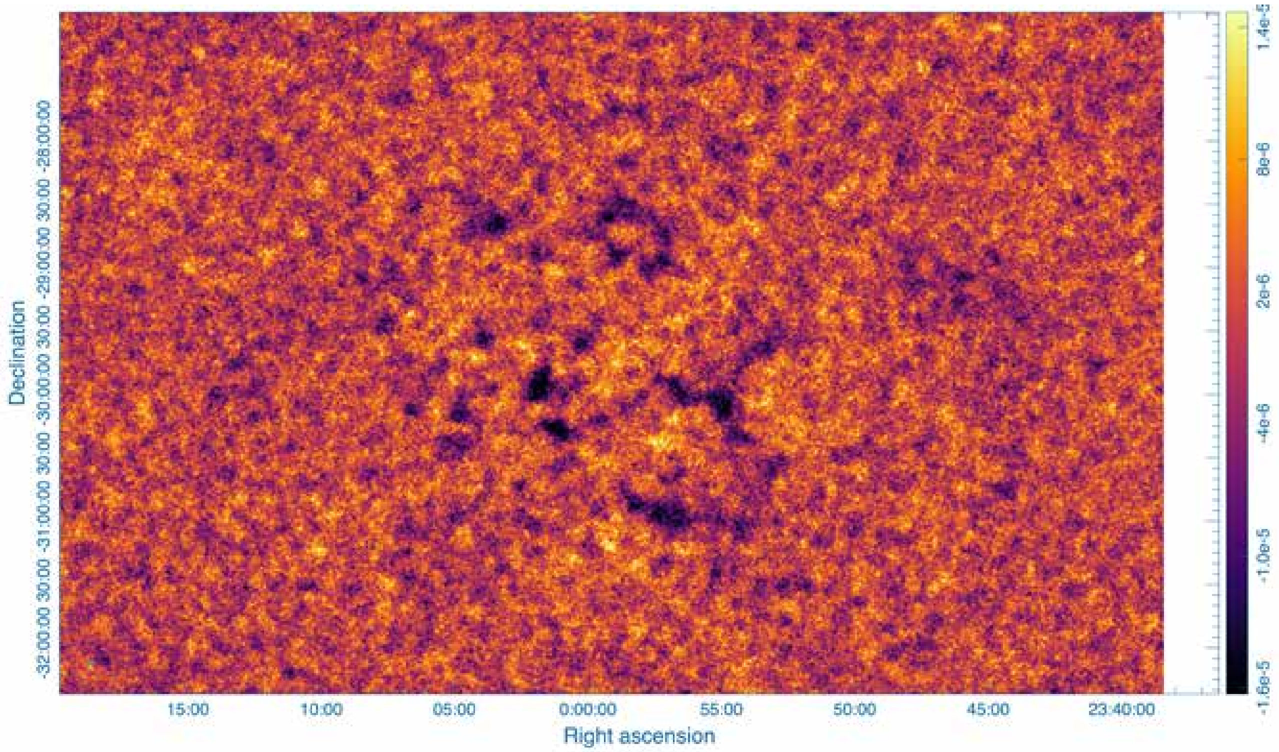
The participants are working to analyse and interpret simulated observations of the Epoch of Reionisation (EoR), the period when the first stars and galaxies began to form. Detecting the extremely faint, low-frequency signal from this epoch is a key science goal for the SKA-Low telescope.

"We know the reionisation happened, and we know roughly when it happened, but there are a lot of details we don't know," said SKAO Senior Scientist Dr Anna Bonaldi.

"There are a lot of possible scenarios. For instance, was this change driven by massive stars or maybe active galactic nuclei? Did the change happen gradually over millions of years, or did it happen all in one quick burst?"

The emergence of the first stars and galaxies profoundly altered the surrounding neutral hydrogen, which emits a distinctive 21 cm radio frequency. As ultraviolet radiation from the first stars and galaxies began to ionise the surrounding hydrogen, it effectively "switched off" the 21 cm emission, a phenomenon the SKAO aims to detect.

Owing to the expansion of the Universe, the wavelength of the emission from this early hydrogen is "stretched" as it travels through space - a phenomenon known as redshift. As a result, by the time it reaches Earth the 21 cm emission has been shifted to longer wavelengths (meaning lower frequencies). The older the emission, the lower the frequency.



The radio sky at 151.2 MHz (corresponding to the power spectrum in the top right) which includes the EoR signal, foreground emission and noise.

"To detect the very faint Epoch of Reionisation signal, we would need to produce a heavily averaged data product called a power spectrum," explains Dr Bonaldi.

Power spectra are a way of showing how intense different signals are across a wide range of frequencies. By comparing the strength of the signal at different frequencies (which, in effect, correspond to different epochs) we can actually pinpoint when the reionisation occurs.

In the challenge, teams are given three power spectra covering the frequency range 151-196 MHz, corresponding to between 605 million years to 895 million years after the Big Bang. They are tasked with tracking the progress of reionisation, a part of the analysis that is called "inference".

"As no telescope has yet detected any signal from the Epoch of Reionisation, we have had to make some assumptions in creating this data, and at the moment we cannot be sure that any of them are correct," Dr Bonaldi noted.

"To try and reflect the level of uncertainty, we have produced two different sets of data with different simulation codes."

These two sets of data incorporate different assumptions; one of the goals of the challenge is to understand how making different assumptions can affect the result.

Previous Science Data Challenges had large datasets (more than 7 TB in the last challenge, which is more than 10 times the capacity of an average laptop), but the power spectra are a compact dataset of just 78 KB – far smaller even than an average smartphone photo.

Teams will need to run analysis models multiple times to test many reionisation scenarios, requiring access to significant computer processing facilities. To meet these demands, 11 computational facilities across Europe, Asia and Australia are providing teams with access to either virtual machines, which simulate powerful computing environments, or high-performance computing systems equipped with job schedulers to efficiently process complex calculations.

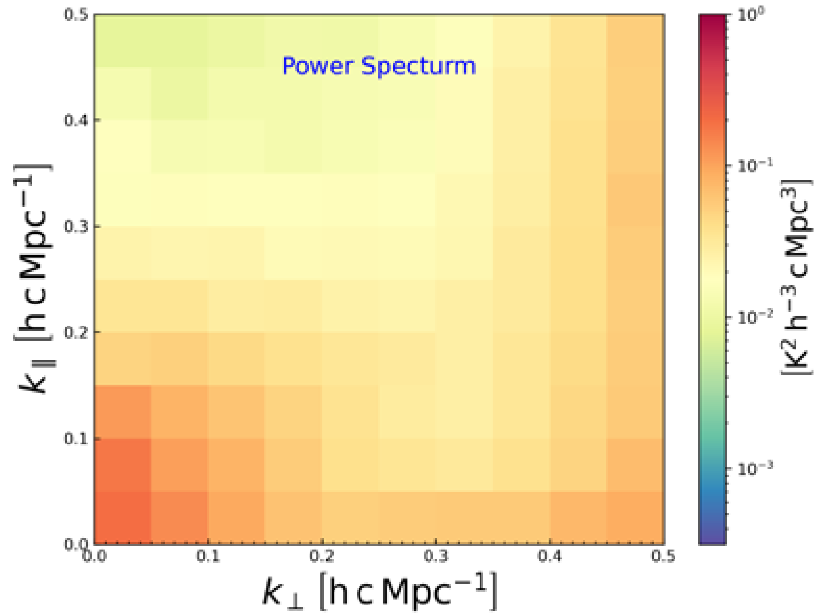
Encouraging community knowledge sharing

Prior to this challenge, there was little opportunity for a community-wide comparison of the models and data processing techniques essential for interpreting signals from the Epoch of Reionisation.

"There are various modelling groups working on different experiments, and while they have carried out validation internally, there simply hasn't been time for a community-wide comparison," said Dr Bonaldi.

"We hope that by going through this process, we will be able to see the level of consensus between the different analysis models that are being used. This will ultimately increase the robustness of the methods and the confidence that we have in our ability to interpret the EoR signal, in preparation for a detection with the real data."

The effort has been welcomed by participants, including Dr Adélie Gorce, Staff Researcher at the French National Centre for Scientific Research (CNRS), who co-leads the ToSKA team, with members in Italy, Australia, and France.



A power spectrum being used in the challenge, with the different colours denoting the level of power in different spatial scales arising from a combination of foreground emission and Epoch of Reionisation along with noise.

The team is upgrading algorithms developed for the Hydrogen Epoch of Reionisation Array (HERA), an SKA precursor telescope in South Africa, including training artificial intelligence on mock data designed to match the sensitivity offered by the SKA telescopes.

"We have plenty of models to predict what the 21cm signal from the Epoch of Reionisation looks like from theory, but no certainty on which one is the 'right' model. The SDC3b is a great opportunity to test how these uncertainties could bias our interpretation of future observations," said Dr Gorce.

"It's also an excellent and necessary opportunity to compare models and techniques within the community and prepare for the design of future key science projects when the SKA telescopes come online."

The structure of this version of the challenge has allowed several teams to build on the knowledge gained from earlier challenges.

"I already understood the data I am dealing with. It eased the load of exploration," said SROT team leader Akash Kulkarni, a PhD student at the Indian Institute of Technology, Dharwad.

"In the process of the project, I get to learn a lot about cosmology as a theory and the instrumentation to be built to study it."

Kulkarni adds that comparing tools and techniques with the community is proving valuable in terms of skills development, too.

"It helps me to know where I stand and how much I know. I would say I am a radio frequency and antenna designer, yet I stand on the leaderboard of a data challenge: wow! That was a great experience and motivation."

MeerKAT spots a troublesome cosmic beast

BY DR JACINTA DELHAIZE (UNIVERSITY OF CAPE TOWN)

South Africa's MeerKAT telescope has uncovered an extraordinary new giant radio galaxy nicknamed Inkathazo, meaning "trouble" in the African Xhosa and Zulu languages, which sheds light on the evolution of the largest structures in the Universe and offers new, yet confusing, insights into their mysterious origins.

Giant radio galaxies are rare cosmic behemoths spewing jets of hot plasma millions of light years across intergalactic space. These plasma jets, which glow at radio frequencies, are powered by supermassive black holes at the centres of galaxies.

Inkathazo's plasma jets span 3.3 million light years – over 32 times the size of the Milky Way.

"It has been a bit troublesome to understand the physics behind what's going on here," said Kathleen Charlton, a master's student at the University of Cape Town and the first author of the study.

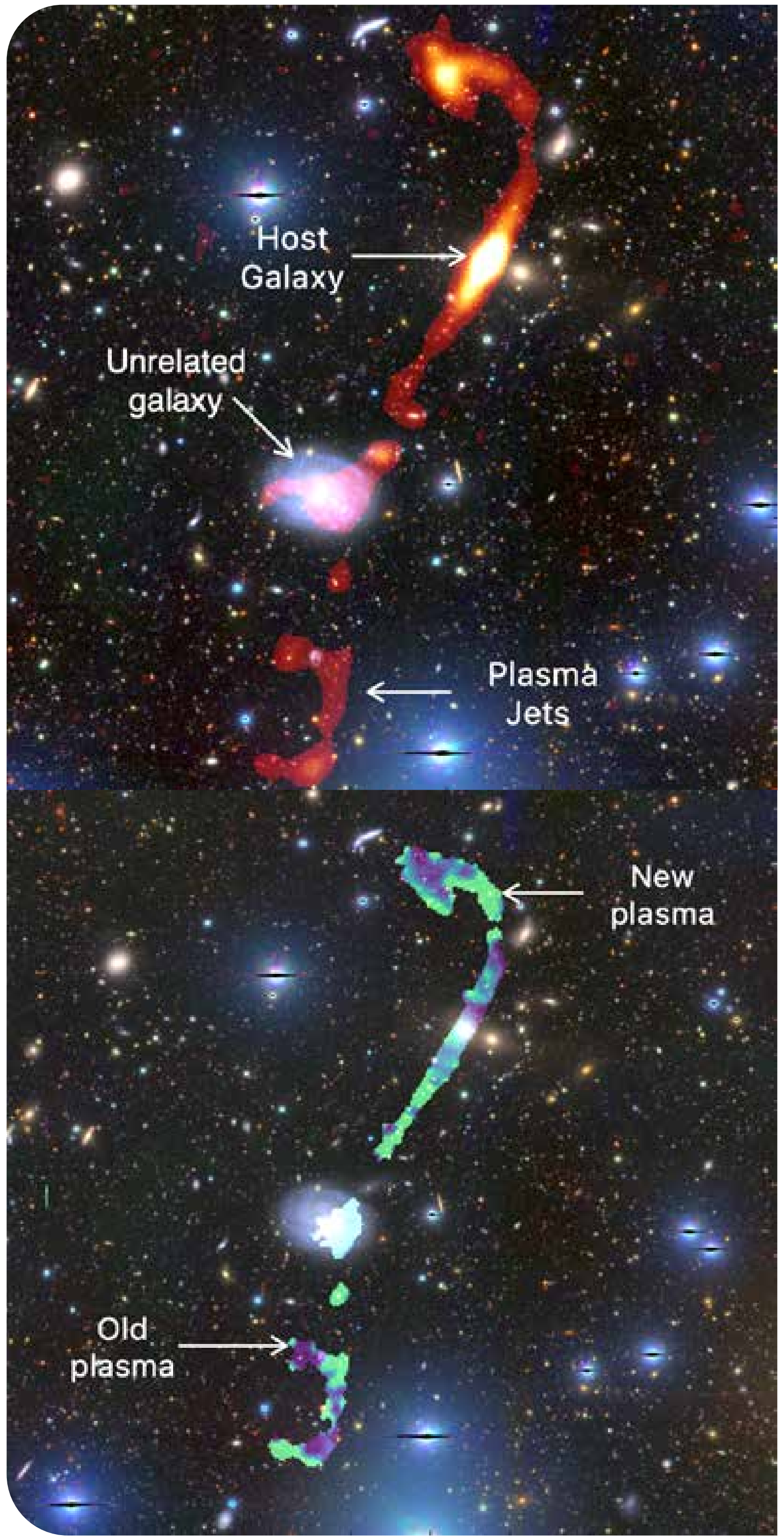
"It doesn't have the same characteristics as many other giant radio galaxies. For example, the plasma jets have an unusual shape. Rather than extending straight across from end-to-end, one of the jets is bent."

Additionally, Inkathazo lives at the very centre of a cluster of galaxies, rather than in relative isolation, which should make it difficult for the plasma jets to grow to such enormous sizes.

Researchers took advantage of MeerKAT's exceptional capabilities to create some of the highest-resolution spectral age maps ever made for giant radio galaxies. The maps track the age of the plasma across different parts of the galaxy, providing clues about the physical processes at work.

The results reveal intriguing complexities in Inkathazo's jets, with some electrons receiving unexpected boosts of energy. The researchers believe this may occur when the jets collide with hot gas in the voids between galaxies in a cluster.

The work, co-authored by several members of the international MIGHTEE collaboration, has been published in the *Monthly Notices of the Royal Astronomical Society*.



Above: The newly discovered giant radio galaxy Inkathazo. The glowing plasma jets, as seen by the MeerKAT telescope, are shown in red and yellow. The starlight from other surrounding galaxies can be seen in the background. The large spiral galaxy seen in the lower-left of centre is actually a much closer foreground galaxy which is unrelated to Inkathazo. Credit: K.K.L Charlton (UCT), MeerKAT, HSC, CARTA, IDIA.

GMRT helps discover longest-ever black hole jets in a remote galaxy 7.5 billion light-years away

SOURCE: NATIONAL CENTRE FOR RADIO ASTROPHYSICS (NCRA)

An international team of astronomers has used India's Giant Metrewave Radio Telescope (GMRT), an SKA pathfinder, to discover the biggest pair of plasma jets that has ever been seen to emanate from a supermassive black hole, spanning a size of 23 million light years from end to end. The size of the jets is 140 times the diameter of the Milky Way.

The jet megastructure, nicknamed Porphyrion after a giant in Greek mythology, dates to a time when our Universe was 6.3 billion years old. These powerful outflows – with a total power output equivalent to trillions of Suns – shoot out from either side of a supermassive black hole at the heart of a remote galaxy.

"In the centre of every major galaxy, there is a big black hole of about a million to a billion solar masses," says Dr Martijn Oei, a postdoctoral scholar at the California Institute of Technology (Caltech) and the lead author of the paper reporting the findings, published in *Nature*.

"It swallows stars, dust and plasma – basically everything that comes close – but a small fraction of the material that comes close to the black hole is ejected outward in the form of such jets."

The gigantic jet system is one of thousands of faint megastructures originally found using Europe's LOFAR radio telescope, also an SKA pathfinder.

To determine the jets' length, another powerful radio telescope was needed that could trace the jets back to the galaxy from which they emerged. Dr Oei's team used sensitive, high-resolution GMRT observations to identify the host galaxy that spawns the jets, then used the Keck I optical telescope in Hawai'i to obtain the distance.

Without the precise position provided by the GMRT observations, it would have been impossible to identify the optical host galaxy and to determine the giant extent of the radio megastructure.

"Up until now, these giant jet systems appeared to be a phenomenon of the recent Universe," Oei says. "But the Universe was smaller in the past and the wispy filaments of the cosmic web that criss-crosses the space between galaxies were closer together, which means that Porphyrion and its siblings from that distant epoch had an extreme reach across the baby cosmic web."

In fact, the diameter of the sphere of influence of Porphyrion's black hole is a third of a cosmic void, where voids are the vast empty stretches of space between the filaments.

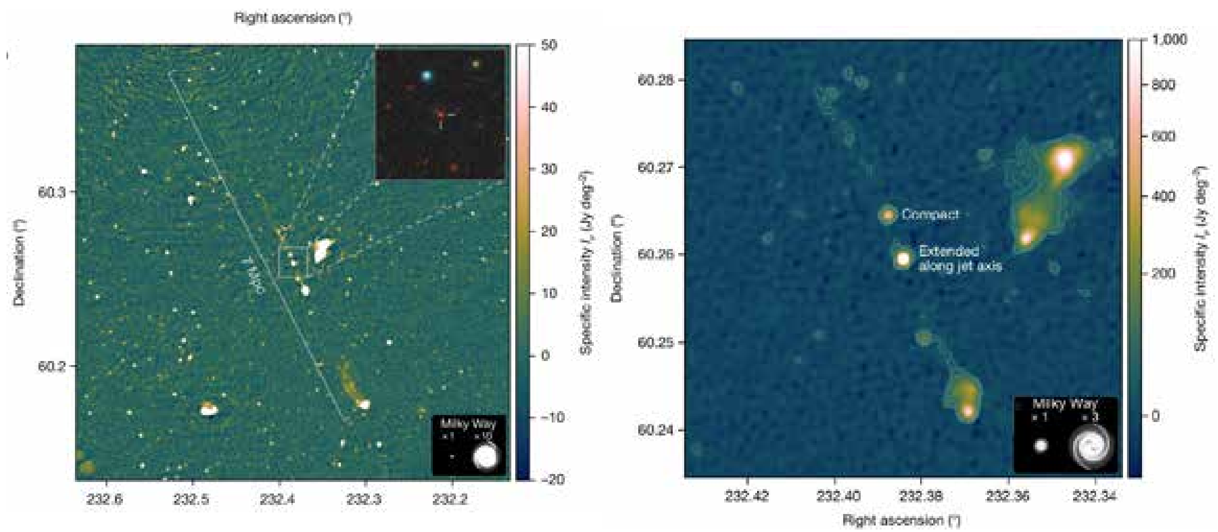
"We may be looking at the tip of the iceberg," Dr Oei says. "Our LOFAR survey only covered 15% of the sky. And most of these giant jets are likely difficult to spot, so we believe there are many more of these behemoths out there."

The triumvirate of telescopes – LOFAR, GMRT and Keck – working in tandem could discover many more giants like Porphyrion in the years to come. How the jets can extend so far beyond their host galaxies without destabilising is still unclear.

Researchers now want to better understand how these megastructures influence their surroundings, particularly the extent to which these giant jets spread magnetism.

Dr Oei says: "We know magnetism starts in the cosmic web, then makes its way into galaxies and stars, and eventually to planets, but where does it start? Have these giant jets spread magnetism through the cosmos?"

Right: GMRT image at a wavelength of 46 cm with a resolution of 4.3 arcseconds. Far-right: The GMRT image of the central region at a higher resolution of 3.6 arcseconds. Credit: Martin Oei



MeerKLASS team presents deepest ever single-dish neutral hydrogen intensity maps

BY DR HILARY KAY (THE UNIVERSITY OF MANCHESTER)

The international MeerKAT Large Area Synoptic Survey (MeerKLASS, PI Mario Santos) collaboration has released the deepest-ever single-dish neutral hydrogen intensity maps, created from 64 hours of data and covering over 200 square degrees of sky. The work has been published in the *Monthly Notices of the Royal Astronomical Society*.

Neutral hydrogen gas is an important tracer of large-scale cosmic structure and is rich in information that can help us understand our Universe. However, the emission is faint and hard to detect. By pioneering a single-dish observing mode using the MeerKAT dishes as individual scanning telescopes rather than an interferometer, the team has been able to employ the technique of intensity mapping (where combined, unresolved emission is measured rather than detecting the individual galaxies and charting their positions) to vast areas of sky.

Exploiting the improved signal-to-noise detection provided by the observations enabled the team to develop a more sophisticated calibration and analysis pipeline. Validating this pipeline using both a suite of mock simulations as well as data from the Galaxy and Mass Assembly (GAMA) survey, the team was able to obtain a statistically significant detection of radio emission associated with the positions of the GAMA galaxies.

"The new signal detection is a great validation of the results from our first pilot survey and demonstrates the fantastic progress on our techniques and pipelines advanced by the team of brilliant scientists behind this result," said Dr Laura Wolz, Deputy-PI of the study.

The MeerKLASS collaboration has recently had its extra-large proposal at MeerKAT accepted, which will see the collaboration conduct a further 500 hours of single-dish observations at lower frequencies, increasing the cosmic volume in the maps by two orders of magnitude.

The MeerKAT radio telescope. Credit: South African Radio Astronomy Observatory (SARAO)

Slow-spinning radio neutron star breaks all the rules

BY RACHEL RAYNER (CSIRO), MANISHA CALEB AND JOSHUA LEE (UNIVERSITY OF SYDNEY)

Most collapsed stars complete a rotation in seconds. This one takes nearly an hour.

Research from the University of Sydney and CSIRO, Australia's national science agency, has uncovered the slowest long-period radio transient yet. Perhaps a neutron star, a magnetar, a white dwarf, or something else entirely, this cosmic lighthouse spins once every 6.5 hours. The previous record was just shy of one hour.

This discovery, found using CSIRO's ASKAP radio telescope on Wajarri Country and published in *Nature Astronomy*, pushes the boundaries of what we thought possible for such objects, which typically rotate very quickly.

Neutron stars, such as pulsars, typically rotate in milliseconds. However, over the past three years a new type of radio transient object – so called because they are detected in radio waves – has been detected, which rotate much more slowly. The mechanisms that allow such a slowly rotating object to emit radio waves is completely unknown.

This slow lighthouse, called ASKAP J1839-0756, also happens to be aligned with Earth in a way that lets researchers see radio waves from both its magnetic poles. This rare phenomenon is a first for objects spinning this slowly.

During a routine observation, ASKAP J1839-0756 stood out because no object had previously been identified at that position. If the observation on this patch of sky had been made 15 minutes later, the team would have missed it.

Such a discovery is thanks to the telescope's wide field of view and regular surveying of the sky, opening up the possibility of these serendipitous discoveries.

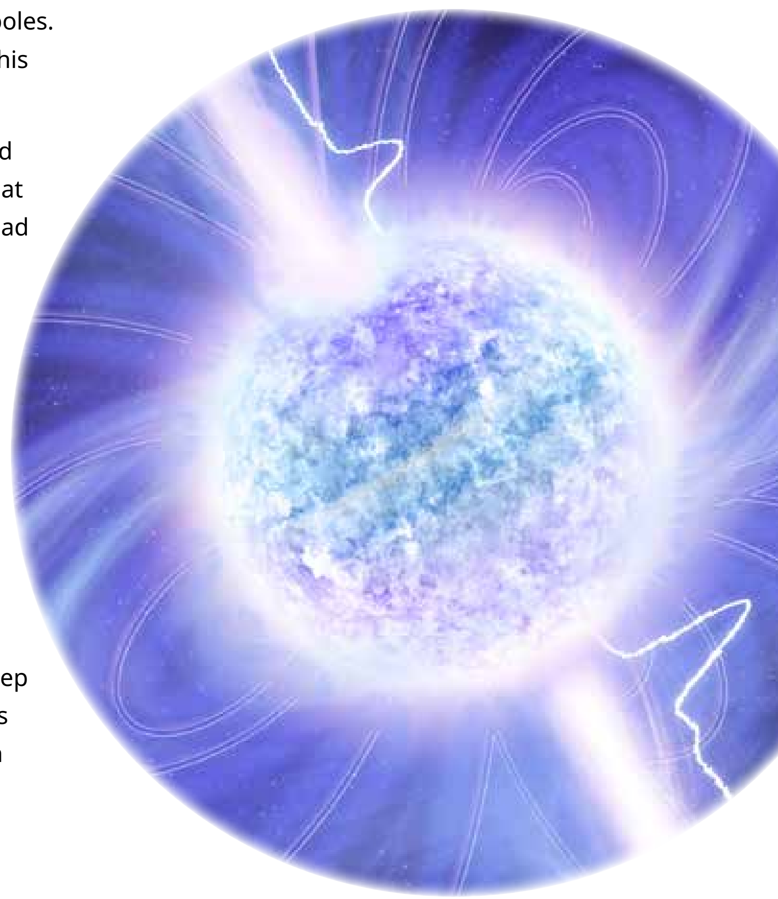
The next step is to work out what the object could be. One possibility is a magnetar – a type of neutron star that is the strongest magnet in the Universe. Magnetars generate radio pulses through a different mechanism to a pulsar, which might allow them to keep shining even at slower spin rates. But even magnetars have limits, and their periods are usually measured in seconds, not hours.

Another possibility is a white dwarf – the leftover core of a star less massive than those that form neutron stars. White dwarfs spin much more slowly than neutron stars, but no individual isolated white dwarfs have been observed to emit radio pulses. And so far no observations in other wavelengths have found evidence of a white dwarf at this location in the sky.

Whatever ASKAP J1839-0756 turns out to be, it is clear that this object is rewriting the rulebook. Its strange combination of slow rotation, radio pulses and interpulses is forcing astronomers to rethink the limits of neutron star behaviour and explore new possibilities.

The discovery of ASKAP J1839-0756 is a reminder that the Universe loves to surprise us, especially when we think we have got it all figured out. As the team continues to monitor this mysterious object, we're bound to uncover more secrets.

Below: Artist's impression of ASKAP J1839-0756. Credit: James Josephides



Astronomers astonished: distant radio bursts strongly resemble neutron stars

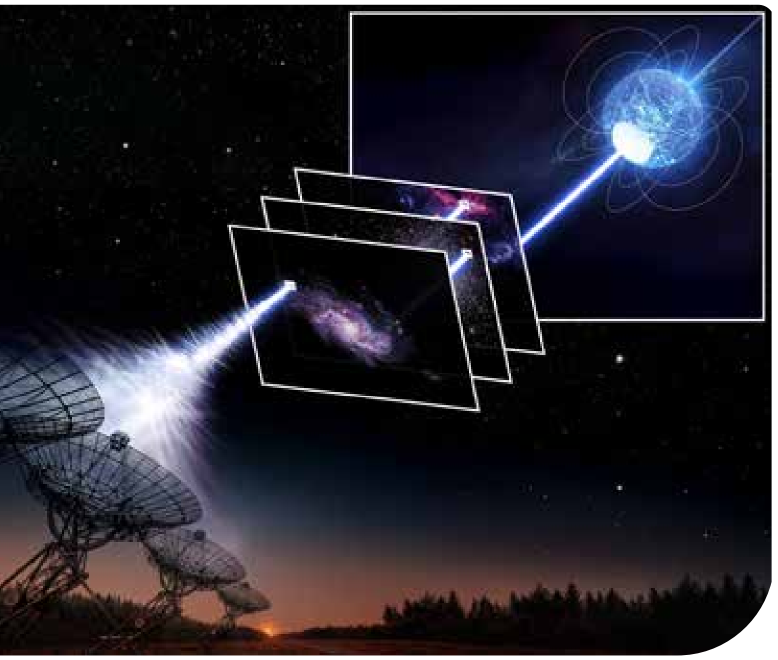
BY ASTRON COMMUNICATIONS

Astronomers have discovered 24 of the as-yet-unexplained fast radio bursts (FRBs) which have a striking similarity to the radio flashes emitted by nearby, known neutron stars.

The findings, published in *Astronomy and Astrophysics*, were made using the Westerbork Synthesis Radio Telescope's Apertif system, an SKA pathfinder technology. They add weight to the theory that neutron stars could be the origin of the mysterious bursts.

The discovery is remarkable because these nearby neutron stars already produce more energy than anything achievable on Earth. The distant stars that emit the FRBs must somehow generate an astounding one billion times more energy than the nearby ones.

FRBs last only about one millisecond, but in that short time they produce more energy than the Sun creates in a month. Up to now, the record holders for power generation were neutron stars, the remnants of exploded stars in our own Milky Way galaxy. The gravity, density and radiation around such neutron stars already amounted to some of the most extreme environments known, visible out to distances of about 100,000 light years. The newly found FRBs, however, shine a billion times more radiantly than neutron stars, reaching Earth from up to one billion light years away, far outside our Milky Way.



Lead author Dr Inés Pastor-Marazuela (ASTRON and University of Amsterdam) explains: "We were able to study these bursts in an incredible level of detail. We find that their shape is very similar to what we see in young neutron stars."

Dr Pastor-Marazuela, currently a Dutch Research Council (NWO) Rubicon Fellow at The University of Manchester, adds that the way the radio flashes were produced and modified as they travelled through space also supports a neutron star origin.

The astronomers achieved this detailed analysis using ARTS, the Apertif Radio Transient System, an experimental supercomputer specifically designed for studying FRBs. In real time it creates and searches well over 1,500 radio beams, the number the SKA-Mid telescope will produce.

"We generally do not know when or where the next FRB will appear," says research leader Dr Joeri van Leeuwen (ASTRON), "so we have a vast computer constantly crunch through all radio signals from the sky."

The system automatically searches for very short, bright bursts from great distances, then zooms in on the data and alerts astronomers.

"We were just starting to think we were getting close to understanding how regular neutron stars can shine so exceedingly bright in radio," says Dr van Leeuwen.

"But then the Universe comes along and makes the puzzle one billion times harder. That's just great."

Left: Highly detailed observations of two dozen fast radio bursts discovered by the Westerbork telescope showed the flashes bore strong similarities to young, magnetised and highly energetic neutron stars, as illustrated here. (Credit: Joeri van Leeuwen/ASTRON)

MHONGOOSE galaxy NGC 5068. The neutral hydrogen is shown in orange/brown, the star formation in purple. The background is an optical image from the Legacy Sky Survey. Note the faint HI extending out from the inner, star-forming gas disc. Credit: J. Healy and the MHONGOOSE team

MHONGOOSE survey takes its final observation

BY PROF. ERWIN DE BLOK (ASTRON)

In December, the final MeerKAT observation of the MHONGOOSE survey was taken. MHONGOOSE, or MeerKAT HI Observations of Nearby Galactic Objects – Observing Southern Emitters, is an ultra-deep HI survey of 30 nearby galaxies, mapping the cool gas in these galaxies down to column densities two orders of magnitude deeper than previous observations.

Each of the galaxies was observed for 55 hours, making this the largest and deepest HI nearby galaxy survey until SKA-Mid comes online in the coming years.

The key science goals of MHONGOOSE, which began in 2020, are to search for signs of gas accretion in the outer parts of these galaxies, as well as to study the relation between gas and star formation in the inner discs.

While the reduction and analysis of the MHONGOOSE data are still in full swing, some intriguing results have already started to come out of the survey.

These include the discovery of an extremely low-mass dwarf galaxy near NGC 1566, a galaxy about 65 million light years away – these kind of galaxies could so far only be studied in the Local Group of the Milky Way and its neighbours. A low-column-density gas disc was found around galaxy NGC 5068, but without signs of interactions, active star formation or inflows, it is not clear what the origin of this component is.

Studies of stacked spectra of the MHONGOOSE data indicate a surprising absence of very low-column-density gas around the sample galaxies, in apparent contradiction to expectations from cosmological simulations. These are just some of the many results that have come, and will continue to come, out of the survey, opening up new queries and investigations. For more information visit the survey website.

Australian innovation ‘sifts’ for mysteries

BY RACHEL RAYNER (CSIRO)

The first trial of an Australian-developed technology has detected mysterious objects by sifting through signals from space like sand on a beach.

Astronomers and engineers at CSIRO, Australia’s national science agency, developed the specialised system, CRACO, for their ASKAP radio telescope to rapidly detect mysterious fast radio bursts and other space phenomena.

The new technology has now been put to the test by researchers led by the Curtin University node of the International Centre for Radio Astronomy (ICRAR) in Western Australia.

Early results enabled by the new technology included the discovery of two fast radio bursts and two sporadically emitting neutron stars, and improved location data of four pulsars. More than twenty fast radio bursts have since been discovered.

Dr Andy Wang, from ICRAR, who led the research group and tested CRACO, said the team had found more astronomical objects than expected.

“We were focused on finding fast radio bursts, a mysterious phenomenon that has opened up a new field of research in astronomy.

“CRACO is enabling us to find these bursts better than ever before. We have been searching for bursts 100 times per second and in the future we expect this will increase to 1,000 times per second,” Dr Wang said.

CRACO is made up of a cluster of computers and accelerators connected to ASKAP at Inyarrimanha Ilgari Bundara, the CSIRO Murchison Radio-astronomy Observatory on Wajarri Yamaji Country. Development of this technology reinforces Australia’s international reputation as a leader in radio astronomy engineering and research.

CSIRO astronomer and engineer Dr Keith Bannister, who along with his team developed the instrument, says the scale of observation enabled by the new technology is enormous.

“CRACO taps into ASKAP’s ‘live’ view of the sky in search of fast radio bursts.

“To do this, it scans through huge volumes of data – processing 100 billion pixels per second – to detect and identify the location of bursts.

“That’s the equivalent of sifting through a whole beach of sand to look for a single five-cent coin every minute,” Dr Bannister said.

CRACO has been engineered to sift through the trillions of pixels received by the telescope to find anomalies, alerting researchers the moment it spots something out of the ordinary, allowing them to quickly follow up to obtain more data and complete their own analysis.

With both fast radio bursts and long-period transients first discovered in Australia, this technology is continuing the tradition of discovery. CRACO will soon be made available to astronomers all over the world as part of CSIRO’s Australia Telescope National Facility, a suite of national research infrastructure which includes Murriyang, CSIRO’s Parkes radio telescope.

“Once at full capacity, CRACO will be a game changer for international astronomy,” Dr Wang said.

The CRACO system was developed through collaboration between CSIRO and Australian and international researchers and was partially funded through an Australian Research Council grant.

Above: Wajarri artist Judith Anaru painted a fast radio burst as part of a series commissioned by CSIRO to celebrate the research being undertaken with CSIRO’s ASKAP radio telescope on Wajarri Country. Credit: Judith Anaru, CRAFT, 2019

Cosmic cartography: mapping the gravitational wave background

BY DR NORBERT JUNKES (MAX PLANCK INSTITUTE FOR RADIO ASTRONOMY)

An international collaboration of radio astronomers used the MeerKAT Pulsar Timing Array (MPTA) as a galaxy-sized gravitational wave detector by monitoring pulsars to nanosecond precision.

Pulsars spin rapidly, emitting a beam of radio waves with each rotation. The clock-like predictability of their rotations allows astronomers to detect faint deviations from their regular behaviour caused by gravitational waves – minuscule ripples in the fabric of spacetime.

The gravitational waves observed with pulsar timing arrays are caused by some of the Universe’s most powerful sources, from supermassive black hole binaries to events just moments after the Big Bang.

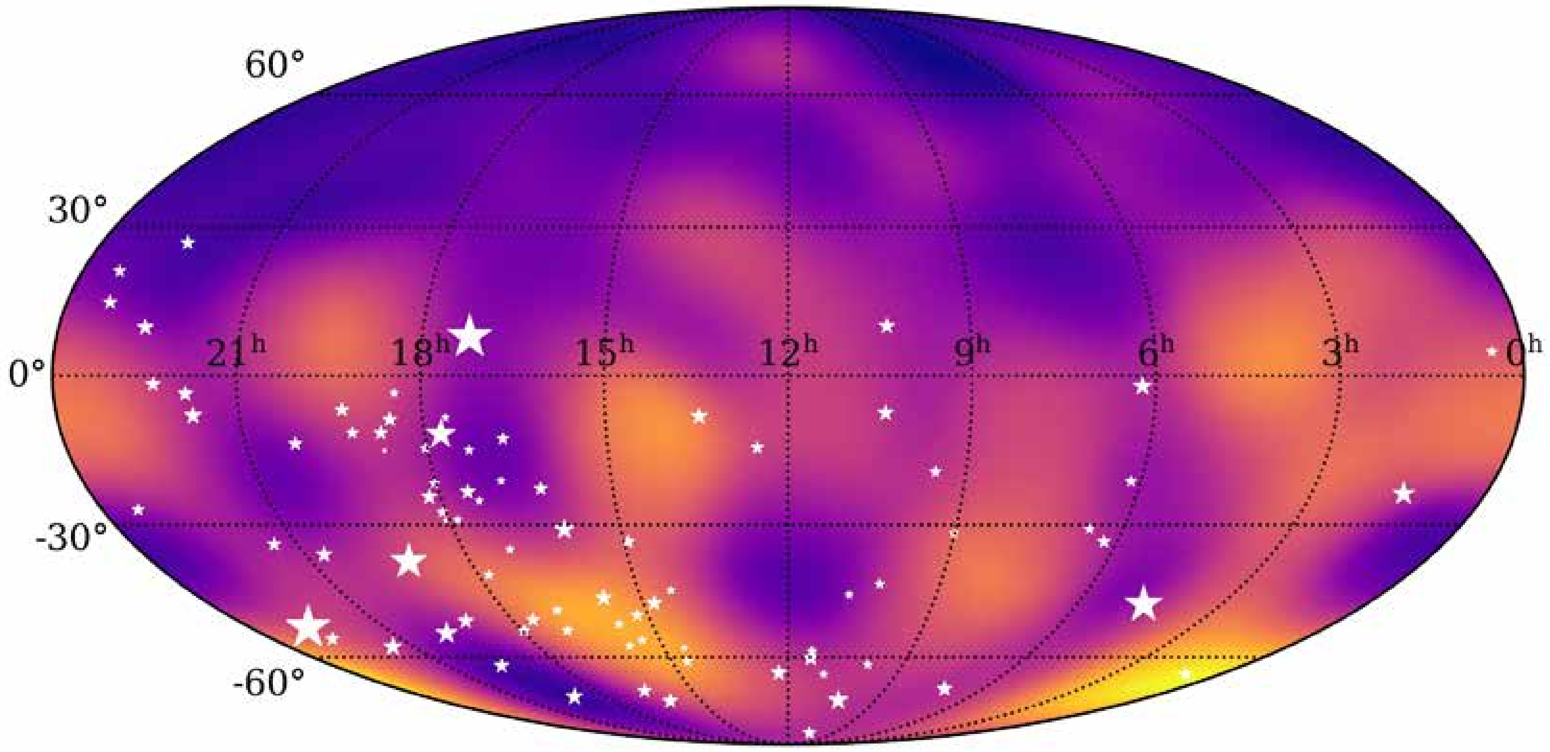
Creating a map of gravitational waves across the sky allows searching for areas with an anomalous excess of gravitational radiation, so-called ‘hot spots’, caused by a single, stand-out supermassive black hole binary, promising insights about the gravitational wave background origin.

Using the largest number of pulsars in any such analysis, and profiting from the high-quality data of the MeerKAT radio telescope, a group of researchers led by Kathrin Grunthal from the Max Planck Institute for Radio Astronomy published the most informative map of the gravitational wave sky so far.

While most parts of the sky did not show notable differences, the research team revealed a small number of intriguing features which will be followed up in future work.

The work by the MPTA collaboration represents a significant leap towards the future of gravitational wave research based on radio astronomy. The results show the crucial role that next-generation radio telescopes, including the SKA telescopes, will play in global efforts to explore the low-frequency gravitational wave Universe.

Below: Gravitational Wave Sky Map obtained from the full 4.5-year-long MeerKAT Pulsar Timing Array dataset. The patchy appearance of the sky map depicts the fluctuations in the amount of gravitational waves coming from different areas of the sky. The yellow regions indicate an excess of gravitational waves, where the brightest spot in the south-east is statistically only moderately significant. The white stars mark the sky locations of the observed pulsars, the size of each star being inversely proportional to the pulsar’s sensitivity. © K. Grunthal et al. 2024



Tianlai joins pathfinder family

BY ANNE DANIELS (SKAO)

China's Tianlai, a hydrogen intensity mapping experiment, is the latest telescope to join the SKA pathfinder family.

Operated by the National Astronomical Observatories (NAOC) of the Chinese Academy of Sciences, the Tianlai experiment is located near Hongliuxia in the north-west of China. It consists of two telescope arrays: the Tianlai cylinder array, which has three adjacent cylindrical reflectors with a total of 96 receivers, and the Tianlai dish array, which consists of 16 dishes, each 6 m in diameter.

Though of relatively small scale, they were built to test the technique of hydrogen intensity mapping, which could be applied to larger arrays such as the SKA telescopes and is already the subject of pilot studies on South Africa's MeerKAT radio telescope (see page 30).

Tianlai aims to shine a light on the mysterious dark energy, which is believed to make up 70% of the cosmos and drives the acceleration of the expansion of the Universe. Although it has never been detected directly, its properties can be derived from the change in the expansion rate of the Universe.

By studying the 21 cm line emitted by hydrogen atoms, the Tianlai experiment is building a 3D map of the large-scale structures in the Universe. This map helps reveal the expansion rate by looking at the "baryon acoustic oscillations" that mark the imprint left behind by the "sound" of the Big Bang on the early Universe. The Chinese experiment was fittingly coined Tianlai which translates to "heavenly sound".

Below: The 16 dishes and three cylindrical telescopes of the Tianlai experiment. Credit: Tianlai project

Team SKA: Dr Catherine Cesarsky

On 3 February 2025 Dr Catherine Cesarsky completed her tenure as Chair of the SKAO Council, passing the role to Dr Filippo Zerbi. This marked the first leadership transition since the Observatory was established in 2021 and concluded Dr Cesarsky's remarkable eight years of service to the SKA project. She had previously chaired the SKA Organisation's Board of Directors, the precursor to the SKAO, since 2017.

Born in France and raised in Argentina, where she also pursued her university education, Dr Cesarsky has had an illustrious career leading some of the most ambitious initiatives in astronomy. She spoke to us about her journey, the challenges of managing large-scale scientific projects, and the advice she wishes she had received as a young researcher.

Let's start with your childhood, Catherine. When did you get interested in science?

It happened relatively late. I grew up in a household deeply immersed in the arts. My father owned a bookstore and an art gallery, and literature was the primary topic of conversation. My two older sisters and I read extensively, but science was absent from our discussions. There were no science books in our home – perhaps with the occasional exception of Jules Verne.

What attracted me to science was my love for mathematics, which was my favourite subject in school. I was fascinated by the connection between mathematics and nature, which naturally led me to physics. In my final years of high school, I was the first girl in my school to specialise in physics and mathematics – and I was also the top student in my class. That experience convinced me that women could excel in science, not because someone told me, but because I proved it to myself.

You studied mathematics and physics at the University of Buenos Aires before choosing physics. How did that lead to studying in the United States?

I hold great admiration for the University of Buenos Aires. I have never encountered another university where professors were so devoted to their students. My astrophysics professor had earned a PhD from Harvard, and his thesis advisor spent time with our group, getting to know us. He later facilitated my, and my husband's, admission to Harvard as graduate students, securing scholarships for us. There were several Argentine students at Harvard and MIT, and we all performed well, thanks to the rigorous education we received in Buenos Aires.

At that point in your career, what were your aspirations?

My dream was to pursue theoretical astrophysics. I was never particularly skilled at building instruments or conducting experiments – I preferred interpreting observations made by others, solving equations and using the early computers available at the time. Computers were still in their infancy when I started, so I envisioned myself working in a small group, or often alone at home at night. This is much like what I did for my thesis and postdoctoral research at the California Institute of Technology (Caltech). I've always enjoyed working at night, and that period suited me perfectly.

You later transitioned from research to leadership roles in major institutions like the French Commission for Atomic Energy (CEA), the International Astronomical Union (IAU), and European South Observatory (ESO). What led you to make that shift?

When I moved to France in 1974, I was a theorist. I received significant recognition for my work, and I enjoyed doing it. Soon, I was leading a group of 11 other theorists in a large lab primarily focused on space experiments This exposure led me into the space science world, and I was invited to join an advisory committee for the European Space Agency (ESA). At the time, there was an ambitious proposal for an infrared observatory, which later became the Infrared Space Observatory (ISO), operational from 1995 to 1998. Having been exposed to pioneering work in infrared astronomy at Caltech, I recognised its potential as the next big frontier in astronomy and put all my energy into getting it selected. I soon got trapped by this new interest.

Catherine (second from left) and her husband (third from left) graduated from the University of Buenos Aires in 1966.

I became the principal investigator for ISOCAM, the infrared camera built mainly in France, leading a team of engineers, technicians, and scientists. Soon after, CEA invited me to head the entire Astrophysics Division. Within just 18 months, I transitioned from theory to managing a laboratory of 150 people. I discovered that I had a talent for organisation, understanding what needed to be done, and motivating people to achieve it.

After ISOCAM was delivered, I briefly returned to scientific research full time, but within a year, in 1994, CEA asked me to lead all physics and chemistry research – overseeing 3,000 people. It was an unexpected offer, and they gave me only one day to decide. I said yes.

As ESO's director-general, you oversaw the Very Large Telescope (VLT) and initiated the construction of the ALMA telescope. Were there any surprises along the way?

Having served on ESO committees and as a Council member, many aspects were already familiar to me. However, the international collaboration aspect was new and fascinating. My priority upon joining ESO was expanding its membership. At the time, there were only eight member states. Securing the United Kingdom's membership was a significant milestone – it enabled us to enter a 50/50 partnership with the United States to build ALMA, an opportunity that would have been financially unfeasible otherwise. By the time I left, ESO had grown to 13 members, with a 14th close to joining, and the detailed study of the next project, the ELT (Extremely Large Telescope, which is now in construction) was launched.

Catherine visiting the Very Large Telescope (VLT) in Chile as director-general of ESO in 2005. Credit: ESO

Having worked across the electromagnetic spectrum, what excites you most about radio astronomy?

My interest in infrared astronomy led me to study galaxy formation and evolution. Radio astronomy offers unique ways to observe this process, particularly through atomic hydrogen, which helps us understand how gas flows into and out of galaxies. Ideally, we can even observe hydrogen from an era before galaxies formed – one of the key scientific goals of the SKA telescopes.

In addition, radio astronomy is crucial for studying cosmic magnetic fields. The SKA will provide ground-breaking insights into their role across different scales, from planets and stars to the intergalactic medium.

What made the SKA project special to you and made you want to be involved?

For many years, European astronomers prioritised two major ground-based projects: the ELT and the SKA. As ESO's director-general, I naturally wanted the ELT to move forward first, but I always recognised that the SKA project was equally essential and complementary.

Being asked to chair the SKA Organisation came as a complete surprise. My predecessor, Giovanni Bignami, had passed away, and I was invited to take on his role. I had worked on many major European scientific organisations, from synchrotron sources to fusion research or particle physics, but the SKA project was uniquely challenging – bringing together a diverse group of countries at the government level, including many new to such international collaborations.

How do you remember that time working on the project?

The challenge wasn't just building the facility – it was also establishing the intergovernmental organisation behind it. By the time I joined, the telescopes' design was already quite advanced, but the real milestone was creating a centralised structure to bring everything together. I focused heavily on the project's organisation, working closely with the director-general and the director of programmes.

Uncertainties are inevitable. For instance, the project has had to adjust to budget constraints over time. That often happens when the reality of costs sets in – ALMA was originally planned to have more antennas, the ELT was supposed to be 42 metres but was reduced to 39 metres, and there are many other examples.

Has the SKAO's progress been typical for a large-scale research infrastructure, or have there been unique challenges?

The biggest challenges the SKAO has faced have been external: the COVID-19 pandemic, the war in Ukraine, and general inflation. These issues affect all projects right now, given the world's particularly complex situation. That said, I'm incredibly proud to see continued support from member countries. Most recently, Sweden signed the SKAO Convention, and France is in the final stage of ratification before joining.

The SKAO Council worked together with Wajarri artist Susan Merry on her artwork *Our Home* during a council meeting in Australia.

Looking back on your time as Council chair, do you have a particular anecdote that you remember fondly that you can share with us?

One amusing moment occurred at the 2022 World Science Forum in South Africa. President Cyril Ramaphosa gave an opening speech, emphasising the importance of the SKA project. When he finished, I was invited to speak. I confidently approached the microphone – only to realise too late that I had taken the president's microphone instead of the one meant for other speakers! It was embarrassing, but the South Africans have a great sense of humour and joked about me "not being president yet."

What's been your impression of the broader impact of the SKAO through your visits to Australia and South Africa, where you've met people from local and Indigenous communities?

I've been extremely impressed. From the very beginning, the SKA project has been open and thoughtful in its approach, gaining invaluable insights from these interactions and fostering meaningful exchanges and partnerships with the original inhabitants of the area.

During my final Council meeting in South Africa last November, we witnessed some of these collaborations firsthand, including support for educational centres. We also had the pleasure of meeting young children who sang for us – it was absolutely delightful. The year before, when the Council was in Australia, many of us participated in a fascinating cultural awareness training, which is also offered to all visitors to the SKA-Low site.

Right now, I'm wearing a shirt given to me by representatives of the Wajarri community, and I love wearing it because it reminds me of the warmth of these interactions. The SKAO has also done an excellent job in employment, successfully involving local communities in the construction process, which is a fundamental part of its ethos.

The collections of Indigenous artworks curated by the SKAO – such as the Shared Sky and Cosmic Echoes exhibitions – are outstanding. These exhibitions have been displayed worldwide, making a significant impact. Engaging in these cultural and scientific collaborations is essential, alongside bringing countries together and, of course, driving forward scientific discovery.

Why do you think countries should consider joining the SKAO?

If you truly want to be involved in the science from the outset, you need to be a member. From a scientific perspective, it's immensely worthwhile. There are also clear economic and societal benefits, but as a scientist my foremost goal is advancing our understanding of the universe. The aim isn't just to share knowledge among a small group of astronomers – it's about sharing discoveries with all of humanity.

Catherine with the South African Minister of Science and Innovation Dr Blade Nzimande at the construction commencement ceremony on the SKA-Mid site.

Many women in STEM see you as a role model. How does it feel to be in that position?

Honestly, despite being the first woman in almost every high-level position I've held – whether as director at CEA, president of the IAU, director-general of ESO, or high commissioner in the French government – I didn't initially realise I was becoming a role model. It's a wonderful feeling, and if it helps give confidence to younger women, all the better.

Throughout my career, I've often taken opportunities to support and advance women's careers, sometimes subtly, but always effectively.

If you could give advice to your younger self – something that might also help those starting their careers today – what would it be?

I would tell her: figure out what you truly want to do and pursue it, no matter what others say. Don't let yourself be led solely by circumstances.

That said, I must admit that if I had strictly done that, I might have decided to stay in my corner doing theoretical work all my life. Instead, I had an exciting career as a director. Would I have been happier if I had stayed with my theoretical work? [cont...]

Above: Catherine with her family and cat, Gatitin.

How have you managed to balance a demanding career with your personal life?

I've been fortunate to enjoy a wonderful family life – with a fantastic husband, two incredible sons, and two lovely grandchildren. Having children was essential for me, even though it did slow down my career at times.

I also love nature and often go hiking, or swimming in the cold waters of the Channel between France and the UK – I actually enjoy cold water! And of course, spending time with friends, watching movies, reading books, and having my cat around all contribute to a balanced life.

Can you choose a highlight from all your experiences?

Being elected to the US National Academy of Sciences in 2004. This was followed by elections to the UK Royal Society the next year and then the French Academy of Sciences. These recognitions are meaningful not just as honours but because they open doors to a world of invaluable exchanges and collaborations.

What's next for you now, Catherine?

Stepping down as Council chair marks the end of a significant chapter. My schedule remains busy, but nothing compares to the responsibilities I had at the SKAO. Now, it's a time for reflection – to decide what I truly want to do next. At this stage in my life, the same fundamental question reappears.

Do you have any final words for the SKAO?

I will continue to follow the SKAO's progress closely and look forward to periodic updates. I will read this magazine with great interest and, above all, I eagerly await the first scientific results. The SKAO has an exciting future ahead!

Images on this page courtesy of Dr Catherine Cesarsky.

SKAO Director-General Prof. Philip Diamond pays tribute to Dr Catherine Cesarsky

Catherine's dedication and tireless efforts for the SKA project have been an inspiration to many of us during her seven-year tenure.

When she joined as Chair of the Board of Directors of the SKA Organisation in October 2017, it was a crucial time, as the project was transitioning from its design phase to becoming a reality.

Since then she has overseen many milestones: the signature of the SKAO Convention in Rome in 2019, followed by the ratification of the treaty and the creation of the Observatory as an intergovernmental organisation in 2021.

I recall during our first SKAO Council meeting that year, Catherine declared it "a historic moment for radio astronomy". Her excitement was palpable, and it set the tone for the momentous journey we were about to embark on, in which she would play a fundamental role.

The SKAO has since has welcomed five new members around the Council table, growing from seven to 12 member countries. Catherine's experience and influence on the global stage were invaluable in this accomplishment.

I've been deeply impressed by and learned a lot from Catherine's ability to navigate complex international collaborations with such tact and determination. Her enthusiasm for the SKA project has been infectious, inspiring all of us to push boundaries and reach for the stars – quite literally.

Catherine has been a trailblazing leader in our field for many decades, and the SKA Observatory is truly privileged to have had her as its first Council chair. I hope the project has made her proud and been a worthy cap to her formidable career.

Above: (L-R) Catherine, Philip Diamond and Ant Schinckel (now SKA-Low Site Construction Director), at CSIRO's ASKAP radio telescope in Australia.

Dr Filippo Zerbi becomes new SKAO Council chair

BY CASSANDRA CAVALLARO (SKAO)

The SKA Observatory Council has a new chairperson, with Italian astrophysicist Dr Filippo Zerbi taking up the role on 3 February 2025.

The intergovernmental organisation's governing body meets three times a year, overseeing the SKAO's funding and strategic direction.

With a long career in astronomy research and instrument development, Dr Zerbi's most recent role was as Science Director at Italy's National Institute of Astrophysics (INAF), where he served two terms from 2016 to 2024. He has been involved in the development and governance of large international research infrastructures and has contributed to the SKA project in various capacities for more than a decade.

Representatives of the SKAO's member states unanimously approved the appointment by election of Dr Zerbi during the SKAO Council meeting in Kimberley, Northern Cape, South Africa, on 5-6 November.

"I am honoured to assume the role the SKAO Council has assigned me, and I am looking forward to contributing to the Observatory's development in this exciting and interesting phase," Dr Zerbi said.

A new vice-chair was also appointed at the meeting, with Inmaculada Figueroa, Vice Director General for International Consortia, Organisations and Research Infrastructures at the Ministry of Science, Innovation and Universities, and Spain's representative on the Council, taking up the role, succeeding South Africa's Daan du Toit.

Dr Zerbi succeeds Dr Catherine Cesarsky, who held the position since the Observatory was founded in 2021 and chaired the Board of Directors of its precursor, the SKA Organisation, from 2017. Read our interview with Dr Cesarsky from page 38.

Below: Group photo taken of the SKAO Council hosted by Switzerland in March 2025. Credit: SKAO

Above: Ambassador Stefan Gullgren signed the SKAO Convention at the Swedish Embassy in London. Credit: SKAO

Sweden on home straight to SKAO membership

BY CASSANDRA CAVALLARO AND JOSH RODDEN (SKAO)

"With this membership, we are investing in the technology of the future, the knowledge of the future, and in basic research of the most inspiring kind."

Those were the words of Sweden's Ambassador to the UK, His Excellency Stefan Gullgren, as he signed the SKAO Convention in January, a process that starts the final steps towards the country's membership.

At the signing ceremony at the Swedish Embassy in London, Ambassador Gullgren said SKAO membership will mean "Sweden is helping to build, run and participate in the most exciting research of our time about our Universe, together with 12 other countries."

Parliamentary approval, expected in the coming months, will conclude the ratification process.

Sweden has made significant contributions to the SKA project in terms of technical and scientific expertise since its inception, and has been awarded two major SKAO construction contracts: for the SKA-Mid telescope's Band 1 receivers, and for the digitisers for SKA-Mid Bands 1, 2 and 3.

In tandem with the event in London, a celebration was held at Chalmers University of Technology in Gothenburg, which has coordinated Swedish contributions to the SKA project since the pre-construction phase through its Onsala Space Observatory. Early-career researchers, including many from abroad, were among those celebrating the moment and the impact it will have on their careers.

"Seeing the work of so many people for so many decades finally be realised and giving us all these new chances, it's really motivating," said master's student Pablo Arriagada Torres. "I'm really excited to participate and, in the future, use observations from the SKA collaboration, and see what's hiding out there in the Universe!"

Video spotlight: Researchers react to Sweden signing SKAO Convention Sweden's radio astronomy expertise attracts young scientists from all over the world to its institutions.

Close-up of an SKA-Mid sub-reflector. Credit: SKAO/Max Alexander

Sub-reflector and cabling contracts awarded

BY MATTHEW TAYLOR (SKAO)

Cabling to link SKA-Low's antennas and a 1,000 km fibre-optic connection between the SKA-Mid telescope and Cape Town are among recent contracts awarded by the SKAO.

Spanish, South African, and Swiss companies are among those benefiting from the agreements.

The largest contract to date for Spanish companies awarded by the SKAO was jointly handed to engineering services company EOSOL and composite materials company COMPOXI, who will manufacture 44 sub-reflectors for SKA-Mid.

The 4.5 m sub-reflector is one of the critical parts of each dish and serves to focus signals collected by the larger main reflector.

Gonzalo Crespo, SKA project leader at EOSOL said: "For EOSOL and COMPOXI to participate in this great project is exciting, as it means being part of one of the greatest scientific challenges of humankind, and at the same time it is a great responsibility. We are really happy that the SKAO has trusted us for this great challenge."

Elsewhere, the UK arm of Swiss cable supplier HUBER+SUHNER has been sub-contracted by Italian antenna manufacturer Sirio Antenne to supply coaxial cabling to connect SKA-Low's antennas.

This will involve the supply of more than 150,000 assemblies of cabling and associated connectors.

Together the components enable a radio frequency signal link between both the antennas themselves and supporting server and data processing facilities.

Chief Operating Officer, Industry Segment, at HUBER+SUHNER Reto Bolt said: "We recognise how this project has the potential to unlock frontiers in science and deepen our understanding of the Universe. We're incredibly proud to be working with Sirio and the SKAO and contributing to collecting this body of knowledge."

Meanwhile, South African ICT firm Gijima has entered a strategic partnership with Finnish multinational Nokia to provide a long-haul end-to-end fibre-optic transmission system.

The network will carry science data 1,000 km from the site of SKA-Mid in the Karoo region of Northern Cape to processing facilities in Cape Town.

Group Sales Director at Gijima Henry Stemmett said the company was "thrilled" to have been selected by the SKAO.

He added: "Our partnership with Nokia ensures that we can deliver a solution that not only meets but exceeds the expectations of the SKAO."

SKAO is key player in software excellence institute

BY MATTHEW TAYLOR (SKAO)

The SKAO is part of a new consortium helping to develop a best-practice framework to ensure research software and code excellence.

Nineteen organisations, including the SKAO, CERN, and the French national research agency CNRS, are involved in the EVERSE project.

Funded until at least 2027 by the European Union's Horizon programme, EVERSE participants will help to standardise approaches for developing research software, maximising software quality and sustainability.

Their collective knowledge will be captured in a Research Software Quality toolkit (RSQkit), which can be used as a guidebook to best practice by current and future research infrastructures across the five European Open Science Cloud (EOSC) science clusters: astronomy and particle physics, environmental science, life science, photon and neutron science, and social sciences and humanities.

The project is split into five different work packages, with the SKAO involved in three, focusing on:

- connecting relevant organisations to build the EVERSE network
- assessing the approaches taken by different research communities and develop common ground for overall best practice
- working towards providing a catalogue of software tools to feature in the RSQkit

The project has taken shape over the past year since its kick-off meeting in March 2024, and on 18 February 2025 the EVERSE network was officially launched for wider participation.

Initial SKAO input is helping define the collection of software tools in the RSQkit to ensures FAIRness – where software tools are Findable, Accessible, Interoperable and Reusable, in line with the Observatory's sustainability commitments.

For a distributed network like the SKA Regional Centre Network (SRCNet), where software development involves contributions from numerous countries and institutions, adherence to FAIR principles is crucial, ensuring seamless integration, interoperability, and long-term sustainability of the collaborative software ecosystem.

"There are clear benefits for the SKAO in engaging with this collaboration alongside other leading research infrastructures. Through EVERSE, the Observatory is helping guide an important exchange of ideas between experts across astronomy and other scientific disciplines," said SRCNet Software Quality Engineer Shraddha Bajare.

"Our involvement is a great vote of confidence in our committed approach to FAIR principles, and recognition that the SKA telescopes and the SRCNet are underpinned by high-quality, sustainable software that will ensure operations across their decadal lifespans," she added.

The project's long-term goal is to establish an ongoing Virtual Institute of Research Software Excellence.

It also aims to support recognition, reward and career development for those who implement the quality assurance practices and policies that it champions.

Two minutes with... Stefania Grazioli, Sirio Antenne Director

Stefania Grazioli heads Sirio Antenne, the Italian family firm manufacturing the first 78,520 of the SKA-Low telescope's antennas. During a visit to SKAO Global HQ earlier this year for a production readiness review, she spoke to us about her pride at seeing SKA-Low take shape, and preparations to ramp up to full-scale production, scheduled for later this year, when Sirio will be turning out more than 3,000 antennas per month!

Welcome to SKAO HQ, Stefania. Tell us about the latest progress on SKA-Low antenna production.

The production readiness review was a crucial milestone for both Sirio's manufacturing process and the deployment of SKA-Low. It confirmed that the major challenges had been effectively addressed and that our manufacturing processes were approved, granting the "green light" for full-scale production. While some minor issues remain to be resolved or optimised, this is a significant step forward in ensuring the smooth and efficient production of antennas.

How is involvement in the SKAO benefitting Sirio?

We have had both the honour and challenge of finding the perfect balance between scientific requirements and industrial manufacturing capabilities. The project's demanding specifications, combined with the required quantities and physical dimensions of the antennas, led us to establish a dedicated production facility equipped with high-productivity automated machinery. The expansion has resulted in new hiring across all levels of our organisation, from production management to operational roles. Approximately 18 employees will be regularly dedicated to SKA-Low at full operational capacity, and we have trained many more in manufacturing, assembly, and quality control processes to ensure continuous operations. As a result of our involvement with the SKAO, we have recently started receiving further business enquiries.

How do your staff feel to be helping build the world's largest telescope?

We have actively involved all our staff in this project, even those not directly working on it, because we believe everyone should feel like they are part of this extraordinary achievement. We've made it a priority to ensure that everyone at Sirio feels connected to and proud of this fantastic scientific endeavour.

It's truly fantastic to see a project that began many years ago finally becoming a reality. We are immensely proud to be part of this incredible endeavour, contributing to a groundbreaking initiative that will expand the boundaries of science and technology.

Opening the door for Team SKA of tomorrow

BY ANNE DANIELS AND GINA PEARSE (SKAO)

The SKAO's sustainability commitments include inspiring the next generation through education and training. Across its three host countries, the Observatory is providing opportunities aimed at attracting students to science and engineering.

Choosing careers in the UK

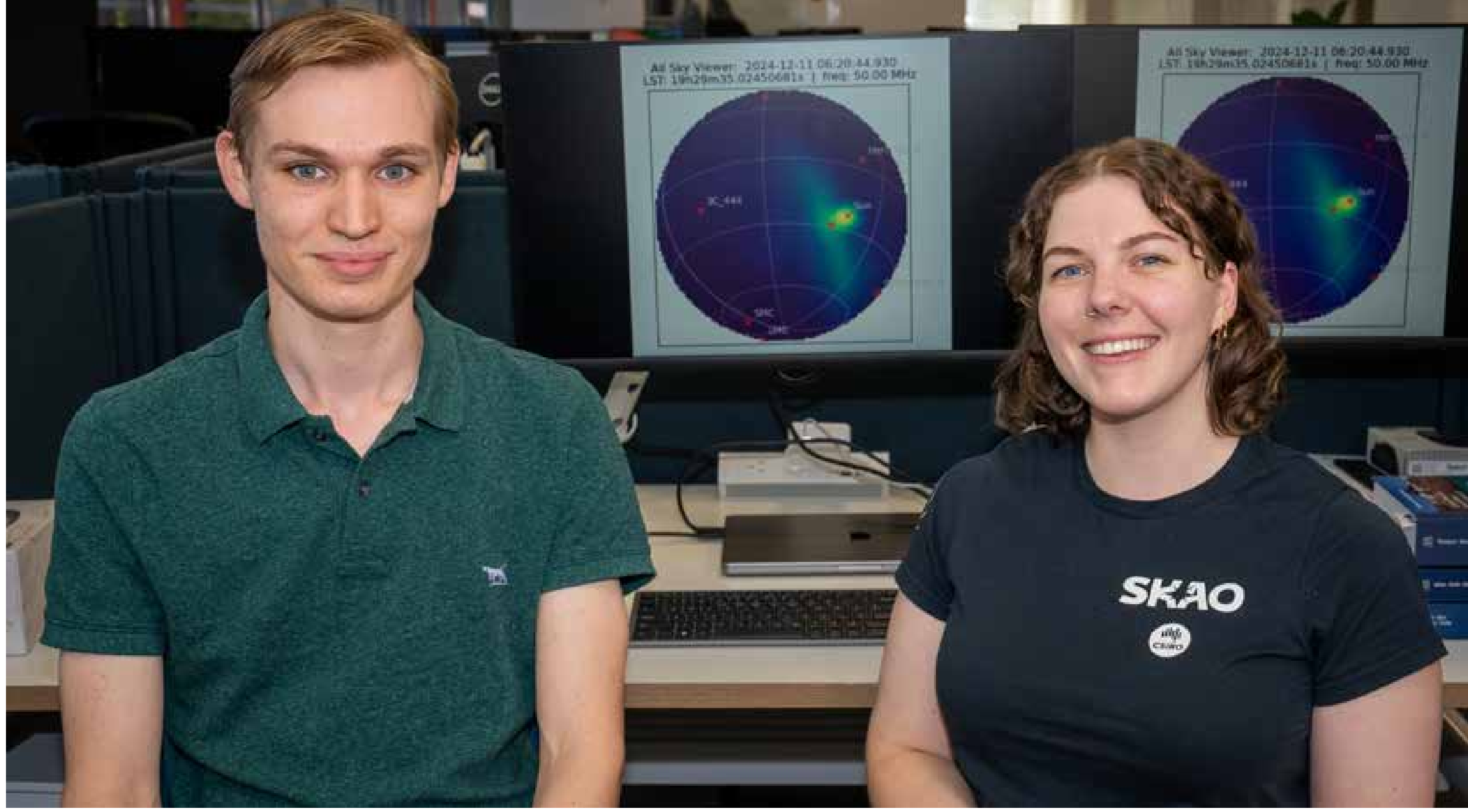
Staff in all three SKAO host countries gave more than 70 students from across the UK a glimpse into life at the Observatory during a three-day virtual work experience in October 2024, through a partnership with the charity Speakers for Schools. Inspirational speakers working in science, engineering, project management and business support roles shared their professional journeys and chatted with students directly through question-and-answer sessions.

Activities included a guided tour of the night sky, a quiz challenging their knowledge of the Universe, and a coding exercise in Python. During a session run by the SKAO's UK partner the Science and Technology Facilities Council, students programmed a virtual Arduino, equipping them with valuable skills.

In a survey, 93% of the students rated the work experience good or excellent, with 90% interested in pursuing a career in the science or engineering industries, and the same figure saying they felt confident about achieving their career ambitions.

"The best thing about the placement was the day in the lives of the different members of staff as it gave an honest insight to what a career within those fields would be like," shared a student afterwards.

In February SKAO Global HQ welcomed 60 pupils from the UK National Citizens Service – which provides opportunities for teenagers from less advantaged backgrounds – in partnership with the neighbouring Jodrell Bank Observatory. They were treated to a live demonstration of the SKAO Table-top Radio Telescope by System Scientist Dr Shin'ichiro Asayama, observing neutral hydrogen in the Milky Way.



"I've been treated as part of the team. Learning how to use the telescope, to calibrate, to take observations, and then running my own analysis on the data, as a full circle, was really a highlight."

SKA-Low team welcomes summer vacation students

Two Australian university students have had the opportunity to contribute to the SKA project, working with teams to operate and observe with an early working version of the SKA-Low telescope.

Lizzy Phillips, who is studying space science at the Royal Melbourne Institute of Technology, used the first pulsar observational data from SKA-Low stations to assist with telescope calibration and to investigate how the ionosphere is affecting incoming radio waves.

"I haven't been treated like a student – I've been treated as part of the team. Learning how to use the telescope, to calibrate, to take observations, and then running my own analysis on the data, as a full circle, was really a highlight," she said.

University of Western Australia student Jasper Fromant focused on characterising radio frequency interference sources for the SKA-Low telescope to better understand the radio environment at Inyarrimanha Ilgari Bundara, the CSIRO Murchison Radio-astronomy Observatory.

Jasper's supervisor, SKA-Low Operations Scientist Danny Price, said that the Undergraduate Studentship Programme offered by CSIRO, the SKAO's collaboration partner in Australia, attracts some of Australia's top STEM undergraduates and is important to the future of the industry.

"Internship programmes like this are hugely important to develop the next generation of astronomers, scientists, and engineers, and to foster a vibrant research environment within the SKAO," he said.

SKA-Mid invites home-schooled learners

In April a group of home-schooled students will be visiting the SKAO offices in Cape Town, South Africa, to see behind the scenes of the Observatory that is being developed on their home turf.

Twenty learners aged between 17 and 18 years old will meet members of the SKA-Mid team, getting an opportunity to hear about the latest construction progress and science goals driving the SKAO, as well as the wider impact it is having in South Africa.

Look out for an update in the next issue of *Contact*.

Above: Summer students Jasper Fromant and Lizzy Phillips worked with the SKA-Low Operations and Commissioning Science teams.

Putting impact at the heart of SKAO

BY MATTHEW TAYLOR (SKAO)

Providing equipment for early learners and kicking off development of a "digital village" e-commerce platform for Karoo artisans were the latest of several tangible outcomes of the SKAO's sustainability commitments realised in recent months.

The Sustainability Action Group was recently established at the Observatory to drive forward the SKAO's sustainability priorities under the guidance of the overarching Sustainability Steering Group.

Sustainability is a foundational principle of the SKAO, underpinning all other activities across the Observatory.

It refers not only to green practices like waste reduction and recycling, but also to building and maintaining long term relationships and looking after the people, places and resources on which we rely and, more generally, maximising the benefits the Observatory will bring to society, in line with the United Nations Sustainable Development Goals.

Here we look at four recent achievements.

Funding early learners

In Carnarvon and surrounding communities close to the SKA-Mid telescope site, the SKAO and the South African Radio Astronomy Observatory (SARAO) are jointly investing in early childhood development centres.

This includes training educators in the Montessori method of hands-on learning and real-world skills development, as well as furnishing centres with furniture and equipment, the goal being to enhance the knowledge and skills of the educators to improve the quality of education provided to the pupils.

"This programme nicely complements existing SARAO initiatives supporting the local education system through bursaries, teacher training, and work experience programmes," explains William Garnier, Director of Communications, Outreach and Education.

"This means that each stage of the education cycle in the towns around the SKA-Mid telescope is now being supported by our organisations, from toddlers to undergrads and postdocs, which is something unique as far as I know."

At their November 2024 meeting in South Africa, the SKAO Council officially inaugurated the first centre which is part of this programme in Carnarvon at a special event celebrating the partnership.

Investing in local and Indigenous artists

Understanding the place and space where the SKAO's telescopes are located is fundamental to the delivery of its mission. Art is one gateway to better comprehending the deep connections which have always existed between local Indigenous people, the land and the sky.

The SKAO's *Cosmic Echoes* exhibition, developed in collaboration with SARAO, CSIRO, and the Wajarri Yamaji Aboriginal Corporation (WYAC), serves that purpose: through visual art, poetry and soundscapes, it explores how the traditional knowledge of Indigenous Peoples living close to the telescope sites resonates in the creativity of living artists.

The Early Childhood Development Centre in Carnarvon welcomed Council with a song last November.

Cosmic Echoes builds on the success of the original *Shared Sky* exhibition. Its world premiere exhibition was at the IAU General Assembly in Cape Town in August 2024, where it received a warm welcome, with hundreds of visitors enjoying the artworks throughout the two weeks of the General Assembly. It was then exhibited at Artscape in Cape Town, in an event organised jointly with the Dutch Embassy in South Africa.

As with *Shared Sky*, the aim is to exhibit *Cosmic Echoes* internationally, providing a lasting global platform for the creative industries and artists based in the communities near SKA-Mid and SKA-Low.

The SKAO's investment in the artwork will facilitate this and future-proofs the works as one complete collection, which predominantly comprises pieces by First Nations Peoples from the Northern Cape of South Africa, and the Wajarri Yamaji People of Western Australia.

Its third exhibition will be in Carnarvon, South Africa – where several of the *Cosmic Echoes* artists are based – in April. It will then go to several universities across South Africa before beginning an international tour in Western Australia, then moving to other SKAO partner countries. The tour will introduce a worldwide audience to Indigenous knowledge systems and the deep connection between sky and stars that have existed at the SKA telescope sites for millennia.

Reducing waste

Among the initiatives spearheaded by the Sustainability Action Group is the move to stop using single-use plastic water bottles at the SKA-Low site, while further engagement is underway in South Africa towards that goal.

Contractors and employees at both sites will be required to reuse and refill multi-use drink containers – an important move towards plastic waste reduction.

This is the first of several practical suggestions from the group that will be implemented over the coming weeks and months.

Collectively, these changes will produce a lasting impact, with the Sustainability Action Group's work firmly embodying the SKAO's commitment to "consider the long-term implications of our plans and decisions and speak out if we identify a risk".

Supporting creative industries

The SKAO will be working with SARAO to develop an e-commerce platform that facilitates the sale of arts and crafts produced by artisan creators in the Carnarvon and wider Karoo region.

Based on the Chinese concept of Taobao Villages, the scheme aims to help rural communities develop their local economy by enabling the sale of wares to a global marketplace.

Initially the project will focus on targeting opportunities for the family members of SKAO and SARAO staff before being rolled out more widely to help local communities make a living.

SKAO Director of Operations Dr Lewis Ball, who chairs the Sustainability Steering Group, said: "These four initiatives are just a small example of the schemes underway across the Observatory and in our communities to live out our sustainability promises.

"From the outset, we've been keen that our approach is consistent with the United Nations' definition of sustainability, which is to meet the needs of the present without compromising the ability of future generations to meet their own needs.

"As construction progresses, we will be sharing more updates across our five sustainability focus areas: science, environmental footprint, education and opportunities, social equity and radio spectrum.

"It's pleasing to see staff across the SKAO put our pledge to be a socially and environmentally responsible organisation into action."

Plans for SKAO Africa programme

In November the SKAO signed a memorandum of understanding with the UK Science and Technology Facilities Council (STFC) with the goal of establishing an SKAO Africa Programme in the next 12 months.

The programme is aimed at developing human capital across the African continent in radio astronomy and related fields such as computer science, building on the substantial work done by the South African Radio Astronomy Observatory (SARAO) – a National Facility of the National Research Foundation – and the South African Department of Science, Technology and Innovation (DSTI) in this area. The agreement complements two memoranda of understanding on human capital development signed with SARAO and the African Astronomical Society during the IAU General Assembly in Cape Town in August 2024.

The SKAO featured in a live stream from the SKA-Low site during the welcome ceremony at ICRI. Credit:CSIRO/Joseph Byford

The SKAO takes centre stage at ICRI 2024

BY LIZ WILLIAMS (SKAO)

In December 2024 more than 400 people from 50 countries travelled to Brisbane, Australia, for the biannual International Conference on Research Infrastructures (ICRI).

The conference brings together experts from diverse scientific disciplines to explore trends, challenges, and issues of significance for global research infrastructures.

This year's themes included sustainability in the face of climate change, and relationships with and engagement of Indigenous Peoples in the construction and operation of research infrastructures, both topics of major relevance to the SKAO.

The Observatory was prominent throughout the event, starting with a live cross to the SKA-Low telescope site at Inyarrimanha Ilgari Bundara, the CSIRO Murchison Radio-astronomy Observatory. Undoubtedly a highlight of the ICRI welcome ceremony, the live cross featured SKA-Low Head of Science Commissioning Dr George Heald and SKA-Low Field Technicians Karen Faulkner and Emily Goddard, who shared the latest progress on the telescope and activities direct from the site.

Other highlights included SKAO representatives presenting at a meeting of the G7's science officials, and Wajarri Yamaji Aboriginal Corporation Aboriginal Liaison Officer Jennylyn Hamlett taking part in a panel discussion on developing research infrastructure partnerships with local and Indigenous communities, in which she spoke about her involvement with the SKA project.

A small number of participants were able to travel to the SKA-Low site prior to the conference, and others got the next best thing: a virtual site visit with a short version of the *Beyond the Milky Way* virtual reality movie giving them a taste of being on site.

ICRI 2024 was a joint effort between Australia's national science agency CSIRO, the European Commission and the Australian Department of Education.

UK's Royal Society to feature the SKA project during summer exhibition

SELECTED FOR
THE ROYAL SOCIETY SUMMER SCIENCE EXHIBITION

BY DR HILARY KAY (THE UNIVERSITY OF MANCHESTER) AND MATHIEU ISIDRO (SKAO)

In exciting outreach news, the SKA Observatory and its UK partner the Science and Technology Facilities Council (STFC) have been selected by the Royal Society to exhibit together at its prestigious Summer Science Exhibition 2025 in London.

From 1-6 July the exhibition will see over 10,000 members of the public, 1,400 school students and teachers and 1,000 invited guests flock to The Royal Society – the UK's national academy of sciences – where they will discover the transformative science the SKAO will enable, the cutting-edge technology bringing its radio telescopes to life and the UK's role in delivering the ambitious project.

The exhibit will feature real hardware, including a full-size SKA-Low antenna and SKA-Mid dish panel, and use immersive and interactive experiences to explore the SKA telescope sites in South Africa and Australia. Accessible content will ensure audiences can learn about radio astronomy in a variety of ways, including tactile models of stellar objects and sounds made by pulsars. Interactive screens will showcase the SKAO science goals. Hands-on demonstrations will allow the public to make their own observations with an affordable portable radio telescope.

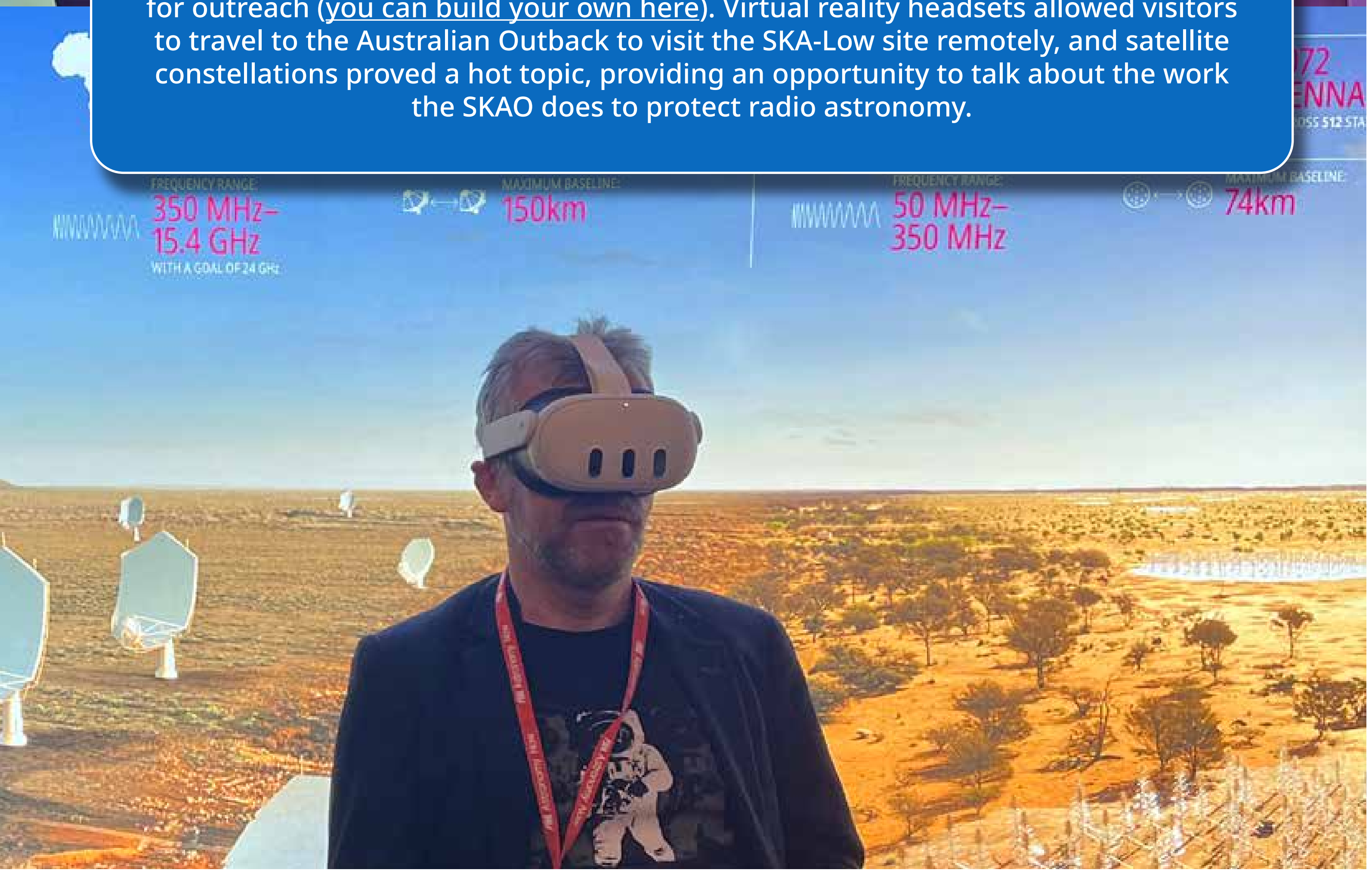
It will also provide an opportunity for visitors to interact with colleagues from across the UK who are part of the engineering and scientific teams developing SKA hardware and software and preparing for future science, showcasing the diversity of people and skills involved in the project

"We are incredibly excited to have this opportunity to share and demonstrate SKAO science and engineering to the public at one of the most historically prominent science events in the UK," said Proposal Lead Chris Pearson of STFC RAL Space.

"Many sciences will be represented but ours will be the only astronomy exhibit. We can't wait to engage with many different age groups, opening their eyes to the amazing global collaboration that the UK is part of and the ways it will change our understanding of the Universe."

Below: The SKAO stand will feature interactive exhibits like those which proved popular with visitors at the IAU General Assembly in 2024.

Outreach was the theme at the hugely popular European Astrofest, held annually in London during the first weekend of February. Universities, amateur associations, astronomy magazines, and telescope manufacturers were among the exhibitors, attracting some 2,000 members of the public. Interest was high in replicating the SKAO's affordable Table-top Radio Telescope developed specifically for outreach (you can build your own here). Virtual reality headsets allowed visitors to travel to the Australian Outback to visit the SKA-Low site remotely, and satellite constellations proved a hot topic, providing an opportunity to talk about the work the SKAO does to protect radio astronomy.



SKAO in the news

IFL Science
The SKA Observatory is set to revolutionize astronomy – we visited for a glimpse into the future
Senior Writer Dr Alfredo Carpineti details his visit to the SKA-Mid site during the IAU General Assembly in August.

Forbes
Astronomers orbiting TRAPPIST-1 star could be peering back at earth
The American business magazine dives deep into humanity's search for extraterrestrial life on the TRAPPIST-1 planets. Renowned astronomer Jill Tarter from the SETI institute explains how the SKA telescopes will aid this search.

Dagens Nyheter
Sverige går in i bygget av världens största rymdobservatorium
The major Swedish newspaper reports on Sweden's signature of the SKAO Convention in January.

IT Web
Gijima, Nokia secure prestigious SKAO business opportunity
South African IT firm Gijima joins hands with Nokia to develop an optical transmission network that will transport science data gathered by the SKA-Mid telescope in the Karoo to Cape Town for further processing.

ABC News
First space image taken by the SKA-Low telescope exceeds expectations
Australia's national broadcaster reports on SKA-Low's first image from the first working version of the telescope.

Cosmos Magazine
SKA-Low telescope's first image of the universe 'just the tip of the iceberg'
The popular Australian science magazine shares SKA-Low's first image with its readers.

Rai News
Leonardo: Scienza e Ambiente [in Italian, from 03:12]
Italy's national broadcaster Rai shares the SKA-Low image on its daily science news programme, highlighting Italian contributions to the Observatory.

Physics World
'Milestone' as Square Kilometre Array Observatory releases its first low-frequency image of the cosmos
UK-based researchers share their views on the first SKA-Low image release.

Times of Malta
Telescope's first image of the universe 'just the tip of the iceberg'
The newspaper reports on SKA-Low's milestone image and highlights the work of Maltese scientists in the SKA project.

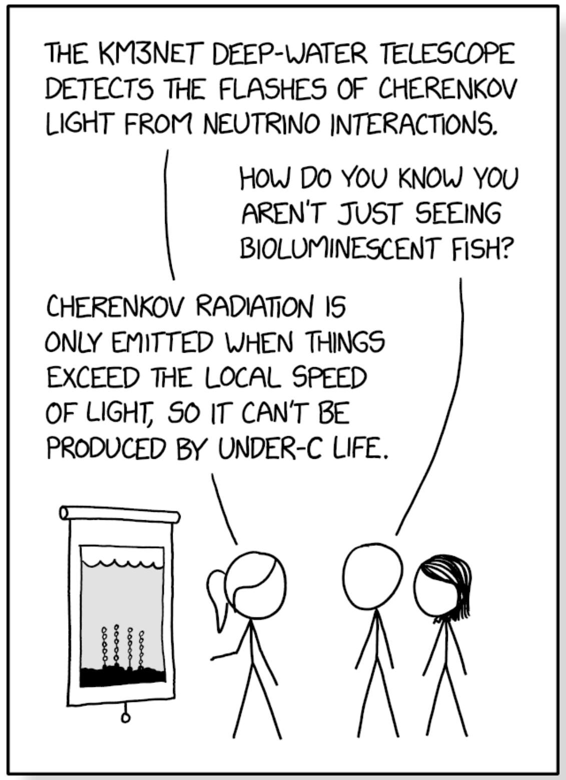
Cartoon Corner

While still under construction, KM3NeT, the cubic kilometre neutrino telescope, has been making waves, with its detection of what could be the most powerful neutrino ever detected.

The underwater telescope, located in the Mediterranean with detectors located off the coast of Italy and France, aims to detect the faint light emitted by neutrinos as they interact with atoms in the large dark volume of water. The source of high-energy neutrinos remains a mystery, but could come from the acceleration of cosmic-rays produced by certain supernovae or gamma-ray bursts.

This particular neutrino is estimated to have been 30,000 times more powerful than what can be created in a particle accelerator on Earth, and the team is currently trying to trace its origin, with a dozen extragalactic sources located along its path being investigated. Read the full article in *Physics*.

Credit: xkcd



We're hiring

JOBS

With construction underway on the SKA telescopes, we continue to recruit staff across a number of areas at our three locations in the UK, Australia and South Africa. Some of the South Africa and Australia-based roles are employed through our partners CSIRO and SARAO. Make sure to register on our recruitment website to receive alerts.

Chief Scientist

The Chief Scientist will be based at the SKAO Global Headquarters at the iconic Jodrell Bank Observatory, Cheshire, UK, and will be part of the executive team reporting to the Director-General. International travel will be required.

APPLY HERE

SKA-Low Operations Scientist

We are looking to recruit an Operations Scientist who will further enhance our growing SKA-Low Science Operations team, in particular with expertise in the areas of the Epoch of Reionisation, Cosmic Dawn, low frequency cosmology, or intensity mapping.

APPLY HERE

Risk Process Manager

The Risk Process Manager will have overall responsibility for the risk management process at Observatory level, combining and re-factoring risks escalated from Directorate-level Risk Registers.

APPLY HERE

Unit4 ERP Developer

Reporting to the ERP System Manager, the U4 ERP Developer will be responsible for development projects in relation to the SKAO's Unit4 Enterprise Resource Planning (ERP) system and its interfaces with other tools across the organisation.

APPLY HERE

Control Software Engineer

The SKA Computing and Software team is looking for two talented Software Engineers to work under the supervision of the Control System Architect and alongside other engineers to ensure that the Control Systems for the two SKA telescopes are developed to the highest standards.

APPLY HERE

Administrator

The administrator will support the Project Managers and the broader Solution Team with administrative, contract, delivery and team support activities helping the teams to focus on delivering the computing and software solutions for the SKAO.

APPLY HERE

Data Processing Software Engineer

The SKA Computing and Software team are looking for multiple Data Processing Software Engineers to work with our agile software engineering teams to build highly scalable processing software.

APPLY HERE

Sustainability Lead

The Sustainability Lead will play a pivotal role driving the development, execution and continuous improvement of the SKAO Sustainability Strategy.

APPLY HERE

SKA-Low jobs via CSIRO

- Verification Systems Engineer (Low System ITF Test Engineer)
- Site Reliability Engineer
- Engineering Management System (EMS) Software Engineer
- Storage Site Reliability Engineer

APPLY HERE

Celebrating our community

In this section we celebrate success and recognise colleagues, partners and members of the community who have received prestigious grants, awards and honours in recent months.

Dr Catherine Cesarsky, who completed her term as Chair of the SKAO Council at the beginning of February, was awarded the Grand Cross in the French national order of merit, the highest rank within the order.

Dr Rob Adam, former managing director of SKAO's partner organisation SARAO, was awarded an honorary doctorate from the University of Witwatersrand in Johannesburg for his exceptional contribution to advancing science, technology and innovation.

Prof. Françoise Combes, former chair of the Extragalactic Spectral Line Science Working Group, has been elected President of the French Academy of Sciences for the period 2025-2026.

The SKAO pavilion at the IAU General Assembly 2024, created in collaboration with Cape Town-based company HOTT3D, won the coveted Best of the Year award at the Exhibition and Event Association of Southern Africa (EXSA).

Dr Renu Sharma, COO and Director of the International Centre for Radio Astronomy Research, has been inducted into the Women's Hall of Fame in Western Australia.

Dr Steve Cunnington (University of Manchester), a member of the SKAO's Cosmology Science Working Group, received the UK's Royal Astronomical Society Early Career Award, which is given to individuals whose career has shown the most promising development within five years of completing their PhD.

The Royal Astronomical Society granted the Group Achievement Award to the European Pulsar Timing Array, who recently published their second data release with high-precision timing data from 25 ultra-stable millisecond pulsars.

SKAO

CONTACT – THE SKAO'S MAGAZINE

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We welcome your contributions to *Contact*!
Get in touch with us at magazine@skao.int

All images in *Contact* are credited to the SKAO unless otherwise indicated.

ABOUT THE SKAO

The SKAO, formally known as the SKA Observatory, is an intergovernmental organisation composed of member states from five continents and headquartered in the UK. Its mission is to build and operate cutting-edge radio telescopes to transform our understanding of the Universe, and deliver benefits to society through global collaboration and innovation.

The SKAO recognises and acknowledges the Indigenous peoples and cultures that have traditionally lived on the lands on which our facilities are located. In Australia, we acknowledge the Wajarri Yamaji as the Traditional Owners and Native Title Holders of Inyarrimanha Ilgari Bundara, the CSIRO Murchison Radio-astronomy Observatory, the site where the SKA-Low telescope is being built.

FRONT COVER

The first image from an early working version of the SKA-Low telescope was released in March 2025, only a year after the first antenna was installed. The image, here depicted in a silhouetted SKA-Low antenna, was created using less than 1% of the full telescope. Read about it on page 12. Credit: SKAO/Max Alexander

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