CONTACT

THE SKAO'S MAGAZINE

ISSUE 15 | APRIL 2024

Contents

Ambassadors and High Commissioners from across several European countries and Australia witnessing progress at the SKA-Mid site. Credit: SKAO/SARAO

Dear friends and colleagues,

Welcome to the 15th edition of the SKAO magazine, Contact.

I'm very pleased to see that, after so many years of preparatory work by many hundreds, if not thousands of people, we see the erection of the first actual SKA-Low antenna and the pedestal of the first SKA-Mid dish.

Both occurred coincidentally (one could say through superb planning ☺)on 7th March 2024. I saw, in person, the SKA-Mid dish pieces on site in the Karoo two weeks prior to the first pedestal being lifted on to its foundation; I then was privileged to insert two of the screws into the SKA-Low antenna #1, ably supervised by one of our young Wajarri Yamaji field technicians. I am expecting progress on the construction to now accelerate rapidly and to see antennas and dishes rise from the Murchison and Karoo.

My visit to South Africa in February was to attend the MeerKAT@5 conference in Stellenbosch. Organised by our South African Radio Astronomy Observatory (SARAO) colleagues, the conference celebrated the first five years of MeerKAT science. I was very impressed with the superb results already emerging from what is a young facility; they demonstrate to me the great promise that will emerge when SKA-Mid, merged with MeerKAT, becomes operational at the end of the decade.

On the middle day of the meeting, a group of us flew to the Karoo to attend a ceremony coinciding with the handover of the first MeerKAT+ antenna from the German contractor OHB to the Max Planck Society, which is the major funder of the 14 dishes being added to MeerKAT prior to its integration into SKA-Mid. It was a month full of significant milestones!

Later in the month, the SKAO Council gathered in Nanjing, China, at the invitation of our colleagues from the SKA China Office and the Ministry of Science and Technology. This was the 11th meeting of the Council and the agenda was comprehensive, covering the many topics on which Council is focused at this time. We took the opportunity to interact with colleagues from the Purple Mountain Observatory, which was very productive and enjoyable.

At the time of writing, we, SARAO and colleagues at the Department of Science and Innovation of the South African government, have just jointly hosted a major diplomatic visit to the SKA-Mid site by ambassadors from 17 European countries, the European Union and Australia. Such visits are a key element of our international relations strategy and we hope are useful in spreading the word about SKAO across the world.

PROF. PHILIP DIAMOND,
SKAO DIRECTOR-GENERAL

Australian students star-struck at observatory site

BY THE WAJARRI YAMAJI ABORIGINAL CORPORATION AND CSIRO

Students from two communities near Inyarrimanha Ilgari Bundara, the CSIRO Murchison Radio-astronomy Observatory, home of the SKA-Low telescope, visited the site on Wajarri Country late last year to experience all the developments happening as SKA-Low construction accelerates.

Eighteen students visited from Pia Wadjarri Remote Community School and Yalgoo Primary School. In outback Australian distances, Pia Wadjarri is right next door at only 45 minutes' drive away whilst Yalgoo is the next suburb over at two hours away.

The full-day event included a VIP behind-the-scenes tour of the observatory, visiting the on-site SKA precursors – the Curtin University-led Murchison Widefield Array (MWA), and CSIRO's ASKAP radio telescope – as well as key SKA-Low construction areas.

A particular highlight was the visit to the SKA-Low prototype station, AAVS3, which is within the MWA site area. Led by Curtin University's MWA Site Lead, students learnt more about the way that the SKA-Low telescope will observe the sky, as well as how celestial objects emit radio waves. It was highly interactive, with students acting as protons, electrons and neutrons which then come together into hydrogen atoms. It was obvious to all that the students were having a great time being subatomic particles!

The students also experienced a real-time feed of an MWA observation and got to go inside the base of one of ASKAP's antennas.

The Wajarri Yamaji Aboriginal Corporation and CSIRO collaborated to host the students on site – we're already looking forward to carrying on the engagement with our Wajarri student neighbours in their next visit where they'll be able to see even more of SKA-Low complete!

We acknowledge the Wajarri Yamaji as Traditional Owners and native title holders of Inyarrimanha Ilgari Bundara, the CSIRO Murchison Radio-astronomy Observatory site.

The students' visit included a trip inside an ASKAP antenna base. Credit: CSIRO

Inspiring Stargirls of the future

BY LIZ WILLIAMS (SKAO)

In early March, the SKAO partnered with the International Centre for Radio Astronomy Research (ICRAR) to deliver the first regional tour of the STEM Stargirls camp in Australia's Mid West.

There was a full house for the event, with more than 40 applicants vying for the 21 available spots at SKAO's new office in Geraldton.

The free event 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 two-day camp was an opportunity to practice real-world astronomy research skills and hear from leading experts in the field.

The camp was delivered by the ICRAR Education and Outreach team, supported by funding and a venue from the SKAO team in Australia.

For the first time, representatives from the Wajarri Yamaji – Traditional Owners and native title holders of the site where SKA-Low is being built – joined the event to share stories of Wajarri cultural connection to sky and Country. Jennylyn Hamlett from the Wajarri Yamaji Aboriginal Corporation and Leonie Boddington from CSIRO spoke at the event, and hosted a Wajarri language workshop, including sharing language used for parts of the observatory and radio telescopes or connected to the sky.

Several SKA-Low team scientists and engineers participated, sharing the latest news about SKA-Low telescope construction. Dr Sarah Pearce and Angela Teale joined remotely from Inyarrimana Ilgari Bundara, the CSIRO Murchison Radio-astronomy Observatory, where they had spent the day installing the first antennas for the SKA-Low telescope. Dr Jess Broderick talked to the students about the excitement surrounding potential SKA science, and all three participated in "speed networking" with the students.

Credit: ICRAR

The sessions also included representatives from SKAO collaborators ICRAR and CSIRO, and a night-time "sidewalk astronomy" event on the first evening.

STUDENTS HAD VERY POSITIVE FEEDBACK:

"The whole thing was an amazing experience, but the networking session was by far my favourite. Being able to talk to people who are so passionate about what they do was wonderful."

"I particularly enjoyed the overall atmosphere during the whole camp. All staff and presenters made me feel very welcome and were always open for questions."

"I enjoyed having the special guests coming in and sharing their pathways they have taken and how they were interactive with everyone."

The team looks forward to hosting similar camps in the future.

Indian and UK astronomers extend SKAO collaboration

BY DR HILARY KAY (UNIVERSITY OF MANCHESTER) AND PROF. TIRTHANKAR ROY CHOUDHURY (NATIONAL CENTRE FOR RADIO ASTROPHYSICS, TATA INSTITUTE FOR FUNDAMENTAL RESEARCH)

Astronomers in India and the UK have received funding from a new Technology and Skills Partnership programme between the UK Research and Innovation's Science and Technology Facilities Council (STFC) and India's Department of Atomic Energy.

The project will see teams at six partner institutions* develop new and existing collaborations, working together on shared SKA-related science interests while addressing the common Big Data processing challenges posed by the SKAO. The collaboration will run from October 2023 to March 2026.

With a focus on enabling and carrying out cutting-edge science with SKA pathfinders, along with developing essential advanced cosmological simulations, the work will help inform the ongoing development of the UK and Indian SKA Regional Centres.

Passing on their expertise, the teams will also help train future generations of SKAO scientists and provide tools and software pipelines for the wider astronomy community. As part of the funding, recruitment of eight new staff across the UK and Indian teams is already underway, along with 16 Indian MSc students who will make work visits to the UK.

"Building collaborations with our global SKAO partners, especially focused on training the next generation, is crucial going forward," said Dr Leah Morabito, co-lead of the project at Durham University, one of the UK universities involved.

> "The tools and software we are developing through this Indo-UK collaboration, will be immensely useful for the analysis of data from pathfinder telescopes like the uGMRT and LOFAR."
>
> PROF. YOGESH WADADEKAR, CO-LEAD OF THE PROJECT AT INDIA'S NATIONAL CENTRE FOR RADIO ASTROPHYSICS (NCRA)

*The six partner institutions are: Durham University, University of Oxford, University of Cambridge, Imperial College London, the National Centre for Radio Astrophysics and the Tata Institute for Fundamental Research.

SKACH scientists win time on top European supercomputer

BY TANYA PETERSEN (SKA SWITZERLAND)

Scientists working with the SKA Switzerland consortium (SKACH) have been awarded the largest ever allocation – 5.5m node hours, corresponding to 22m Graphics Processing Unit (GPU) hours – on the LUMI supercomputer in Finland to conduct a simulation looking at the role of turbulence and gravity in the universe.

The simulation is helping to drive the development of codes, enhanced by high-performance computing and machine learning techniques, to handle large data streams, such as those expected from the SKA telescopes.

The researchers have developed a leading-edge hydrodynamics code called SPH-EXA that is capable of simulating the behaviour of fluids and plasmas on supercomputers, and this simulation will investigate the formation of protostellar cores, the progenitors of stars like our own Sun.

"Understanding this will help us to know the distribution of masses of stars which has important implications for the observable properties of galaxies. This is equivalent to the largest turbulence simulation that has ever been done but for the first time we are including self-gravity, which is what we need for the stellar cores to collapse. It's a major challenge because doing the calculations with gravity requires a lot of computational power," explained Dr Rubén Cabezón, co-principal investigator based at the University of Basel.

Another important element of the project is testing the code itself, to assess any bottlenecks or inefficiencies in the way the simulation uses the system. This work is imperative to large scale simulations that are being developed within the SKACH community, in preparation for future complex processing of SKA telescope data.

Developed for the EuroHPC Extreme Scale Allocation Call, the LUMI-G allocation was awarded for the project: "TGSF: The Role of Turbulence and Gravity in Star Formation, Unveiling the sonic scale with Smoothed Particle Hydrodynamics".

Above: LUMI supercomputer. Credit: Fade Creative

Affixing the pedestal of the first SKA-Mid dish onto its foundation.

SKA-Mid construction highlights

BY TRACY CHEETHAM, SKA-MID SITE CONSTRUCTION DIRECTOR

21st century radio astronomy on the move!

November 2023 saw the beginning of the long-awaited *groot trek* (Afrikaans for great trek) across the seas for the first SKA-Mid dish destined for site in South Africa. During its more than 16,000-km journey from the CETC54 factory in China to the port of Cape Town, technology enabled the excited awaiting South African team – and the wider Observatory! – to follow online the shipment in real time, and that of a ship carrying components for the second dish, which followed shortly after. From the port, the dishes made their way by road to their final home in the Karoo in early February.

There were goosebump moments for the teams on the SKA-Mid site when the trucks started arriving with the new equipment and the hardware was offloaded in readiness for the assembly of the dishes to commence. The two SKA-Mid dishes now on site will form part of the first milestone for SKA-Mid construction, known as Array Assembly 0.5 (AA0.5) due for completion in the first quarter of 2025. AA0.5 will comprise four dishes which will be tested and verified before full-scale production of the dishes proceeds.

The assembly of the first dish commenced with the dish pedestal being raised onto its antenna foundation. The CETC54 team then proceeded with the assembly of the main dish reflector consisting of the main reflector support, counterweight, and reflector panels, before the “big lift” onto the pedestal can take place in the next few weeks.

The first feed indexer has also arrived on site after being shipped from Italy, and is ready for installation on the first dish once the big lift has taken place.

Construction of the contractor camp

SKA-Mid infrastructure contractor Power Adenco Joint Venture took occupation of the contractor camp at the end of January 2024. Equipment and electronic devices deployed at the camp have been certified, and radio frequency interference (RFI) permits were issued by the South African Radio Astronomy Observatory (SARAO) to ensure these devices do not cause radio interference with the MeerKAT radio telescope, approximately 25 km away from the camp.

Construction of new roads is underway in the telescope’s core area where the highest density of SKA-Mid dishes is located. This has to be carefully managed, to ensure that the existing infrastructure already in place for MeerKAT is not damaged.

Importantly, the installation of a new low-frequency communication network is in progress which will give the site-based teams the ability to communicate with hand-held and fixed communication devices that are critical from a health, safety, and security perspective.

AA0.5 server equipment installed

The AA0.5 server equipment and switches were successfully installed by the SKA-Mid Software and Computing team in the Karoo Array Processor Building on site. The Science Data Processor is one of the workloads running on the platform. Other workloads are for control, monitoring, and observations for AA0.5, and the software running on the platform will take the correlated outputs of four individual dishes/telescope observations and aggregate them into a larger, single virtual telescope output.

Health, safety and environment including heritage conservation

Health, safety and the protection of the environment is crucial to the successful delivery and operation of the SKA-Mid radio telescope. A contract has been awarded to EmergencyResponse24 for the provision of emergency medical services on site, which includes two ambulances customised and RFI-certified for operation on site, with two advanced life support and two basic life support paramedics.

Environmental walkthroughs continue on site to ensure that protected flora species are preserved and infrastructure is not routed through highly sensitive aquatic and heritage areas which were identified in the SKA-Mid Integrated Environmental Management Plan.

Local community participation

As part of its “social licence to operate,” the SKAO has contractual conditions in place for large construction contracts to ensure local community participation, and enable the upliftment of the local economy around the SKA-Mid site. Collaboration with Power Adenco has been truly fruitful in this respect, and close to 100 people have now been hired from the four key towns around the telescope site to work on construction activities. In addition, 10 local community members are currently undertaking accredited learnerships for training.

Overall, this quarter has been the busiest of the construction phase of SKA-Mid and it has been a highly charged time with nervous excitement, anxiety, jubilation and most of all, solid progress within the global collaboration teams working to realise the installation of the AA0.5 dishes over the next few months.

Left: The pedestal is lifted into position.

Below: Dish panels on site, waiting to be assembled. Credits: SKAO/SARAO

SKA-Low construction highlights

BY ANT SCHINCKEL, SKA-LOW SITE CONSTRUCTION DIRECTOR

March was a month of many firsts for the SKA-Low team. From the arrival of the first antennas, to the beginning of work for the team who will be assembling and installing them, it's an exciting time at the SKA-Low site.

First antennas installed

The SKAO achieved a major construction milestone in March with the first of the SKA-Low antennas assembled and installed at Inyarrimanha Ilgari Bundara, the CSIRO Murchison Radio-astronomy Observatory.

The SKA-Low team, alongside contractors, have been working hard since the first earthworks for the antenna arrays that comprise AA0.5 – the first four stations of the telescope, on the southern spiral arm – began in September 2023. This includes the infrastructure, consisting of the mesh ground plane of the station, and laying power and optical fibre cables, ready for the antennas to arrive on site, as well as the roads and buildings.

Antennas will now continue to be installed at an increasing pace, alongside more infrastructure construction including laying mesh stations and connecting power and fibre to other clusters on the southern spiral arm, and installing the buildings that will hold the computers needed to combine the signals from the antennas.

Field technicians begin work

The arrival of the first SKA-Low antennas also marked the start of on-site work for the field technicians, who are tasked with the massive technical challenge of building, and eventually maintaining, the 131,072 antennas of the SKA-Low telescope.

Wajarri Enterprises Limited Chairman Des Mongoo and SKAO Director-General Prof. Philip Diamond mark the installation of the first SKA-Low antenna with a handshake. Credit: SKAO

The initial group of 10 field technicians, seven of whom are from the Wajarri community, are the first employees hired in technical roles to build the antennas on site.

The field technicians were recruited to participate in a 12-month training programme, established by the SKAO and CSIRO. The training programme is intended to provide the skills they need to build the SKA-Low telescope, as well as transferable skills that will improve their long-term job prospects. The SKAO and CSIRO teams worked closely with the Wajarri Yamaji to encourage recruitment of Wajarri employees in these roles (read more on page 12).

SKA-Low construction camp opens

March also saw the official opening of the SKA-Low construction village, Nyingari Ngurra, a 176-bed purpose-built camp that provides accommodation to staff and contractors as they continue to undertake crucial infrastructure work across the SKA-Low site. The opening of the village was celebrated with a dinner, as well as a performance from a local Western Australian Aboriginal band – Red Ochre – and the gifting of the traditional Wajarri name that translates to "home of the zebra finch".

First Remote Processing Facilities arrive

The first Remote Processing Facility was successfully delivered and positioned on the southern spiral arm at one of the AA0.5 locations (S9). Throughout March another three of these facilities were delivered and installed at the site, including at the cluster of stations that is now home to the first SKA-Low antennas. These facilities will receive the signals from the far-flung stations along the SKA-Low's spiral arms, before sending them on to a Central Processing Facility.

Left; SKA-Low Field Technician Emily Goddard assembles an SKA-Low antenna.

Right; SKA-Low Licenced Electrician Peter Sudran and SKA-Low Head of Engineering Operations Angela Teale get ready to install the first SKA-Low antenna.

Credits: SKAO

SKA-Low field technicians begin important work on Wajarri Country

BY SEBASTIAN NEUWEILER (SKAO)

The team tasked with the enormous technical challenge of building and installing the more than 130,000 antennas of the SKA-Low telescope have started their critical work in Western Australia.

The initial group of field technicians are the first employees hired in technical roles to build the antennas on site at Inyarrimanha Ilgari Bundara, the CSIRO Murchison Radio-astronomy Observatory.

A particular effort has been made to encourage Wajarri Yamaji applicants, and currently 70% of the field technicians are Wajarri employees.

They are part of a unique 12-month programme, co-designed and delivered by the SKAO with CSIRO, representatives from the Wajarri community and Central Regional Technical and Further Education institute in Geraldton, which provides the field technicians not only with the skills to build the telescope but also ensures the technicians will have long-term benefit through skills applicable to the telecommunications and mining industries, which are highly active in the area.

SKA-Low Field Technician Lockie Ronan said working in the region where his parents and grandparents are from has helped him feel closer to his heritage.

“It’s very meaningful for me to work out here. I feel close to the land and my culture,” he said.

“I think it opens a lot of doors for young Indigenous people to come out here and connect with the land and maybe appreciate the Country a bit more.

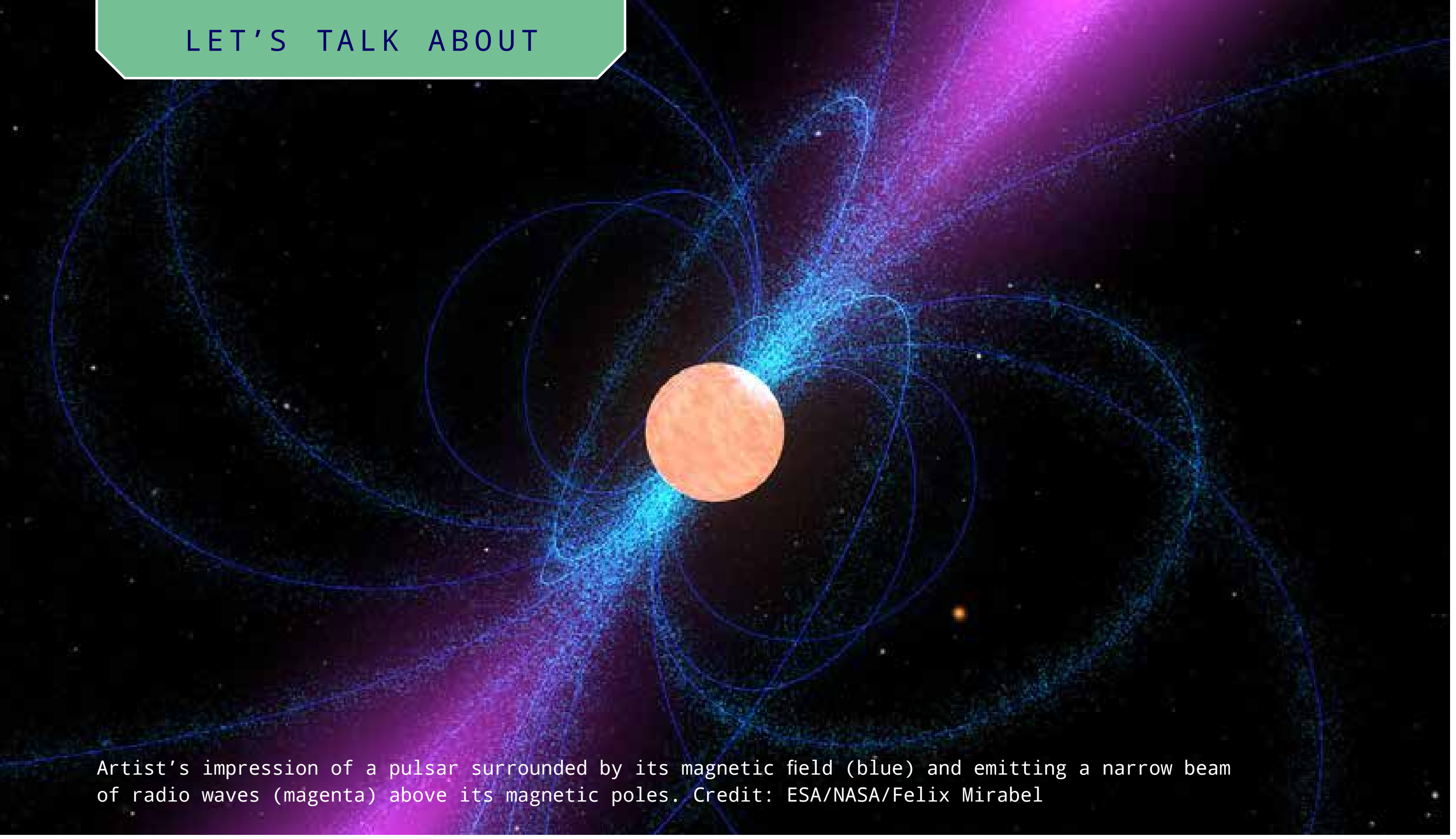
“My parents and grandparents are proud to know I’m out here working on this project on my pop’s land.”

SKA-Low Head of Engineering Operations Angela Teale said: “It’s just so exciting to have our field technicians actually on site working, putting antennas together and installing them to become part of the telescope. I am over the moon that Wajarri make up over 70% of the team.

“One of the field technicians’ grandfathers told me that once the Wajarri get back on the land, the land will begin to bloom. I just thought that was one of the most beautiful things.”

> “It’s very meaningful for me to work out here. I feel close to the land and my culture.”
>
> LOCKIE RONAN, SKA-LOW FIELD TECHNICIAN

Lockie Ronan is one of the first field technicians working to build and install the SKA-Low antennas.



Artist's impression of a pulsar surrounded by its magnetic field (blue) and emitting a narrow beam of radio waves (magenta) above its magnetic poles. Credit: ESA/NASA/Felix Mirabel

Let's talk about… pulsars

BY CASSANDRA CAVALLARO (SKAO)

In January, astronomers announced they had found a mysterious object lighter than the lightest known black hole, but heavier than the heaviest known neutron star, therefore known as a "mass-gap object" (see page 25). It was detected thanks to its effect on its orbital companion: a millisecond pulsar.

Pulsars are the corpses of huge stars that have gone out in a blaze of glory. When a massive star gets to the end of its life and explodes in a supernova, its core undergoes a gravitational collapse. If its mass after the supernova is greater than three times the mass of our Sun, then a black hole is formed, but if it's less than that then gravity continues to compact the matter until a neutron star is formed, so-called because the force of the gravitational collapse crushes protons and electrons together, leaving neutrons.

A neutron star is almost unimaginably dense. It has a mass similar to the Sun, but measures only around 20 km across. Our friends at NASA have calculated that a single sugar cube made of neutron star material would weigh around a billion tonnes on Earth – that's more than 99,000 Eiffel Towers!

Many neutron stars spin rapidly, sending out a stream of radio waves as they do so which can be observed by radio telescopes on Earth. As we can only see the radio waves when the stream points towards Earth, it appears like a pulse, hence the name "pulsars".

"Pulsars have really strong magnetic fields, and because they're spinning rapidly, the magnetic fields act as a dynamo, accelerating particles towards the pulsar's magnetic poles at close to the speed of light," explains Dr Hao (Harry) Qiu, astronomer and SKAO radio spectrum scientist.

The pulses are often compared to the beam of a lighthouse, so regular and reliable that any variation in the arrival time of that pulse as observed from Earth can be used to infer the effect of another object – as in the case of the mass-gap object mentioned earlier – or cosmic incident.

We'll get more into the physics of their behaviour shortly, but first, some history.

Discovered in 1967 by Prof. Dame Jocelyn Bell Burnell, then a graduate student, pulsars have been at the centre of some of the biggest discoveries in astrophysics. In 1992, the first confirmed exoplanets were detected by observing their effects on the pulsar they were orbiting.

Twenty years earlier, the first indirect evidence that gravitational waves exist came from observations of a pulsar in a binary system, a discovery that would later win the Nobel Prize.

Speaking of that most coveted of awards, Dame Jocelyn's contribution was infamously overlooked when the Nobel Committee bestowed the 1974 prize for physics on her supervisor, Prof. Antony Hewish, "for his decisive role in the discovery of pulsars". Prof. Hewish shared the prize that year with Prof. Martin Ryle. Dame Jocelyn is now a highly decorated and world-renowned astrophysicist.

To date, more than 3,300 pulsars have been found, almost all of them within the Milky Way – only 1% have been found beyond our galaxy, in the Magellanic Clouds.

Back to pulsar behaviour. Perhaps the most obvious question is: why do they spin?

"When a pulsar is created from a supernova, it often retains the spinning momentum of the giant star that exploded. As it is roughly five to 10 times smaller in mass, the newborn pulsar will be spinning at a very fast rate," Harry says.

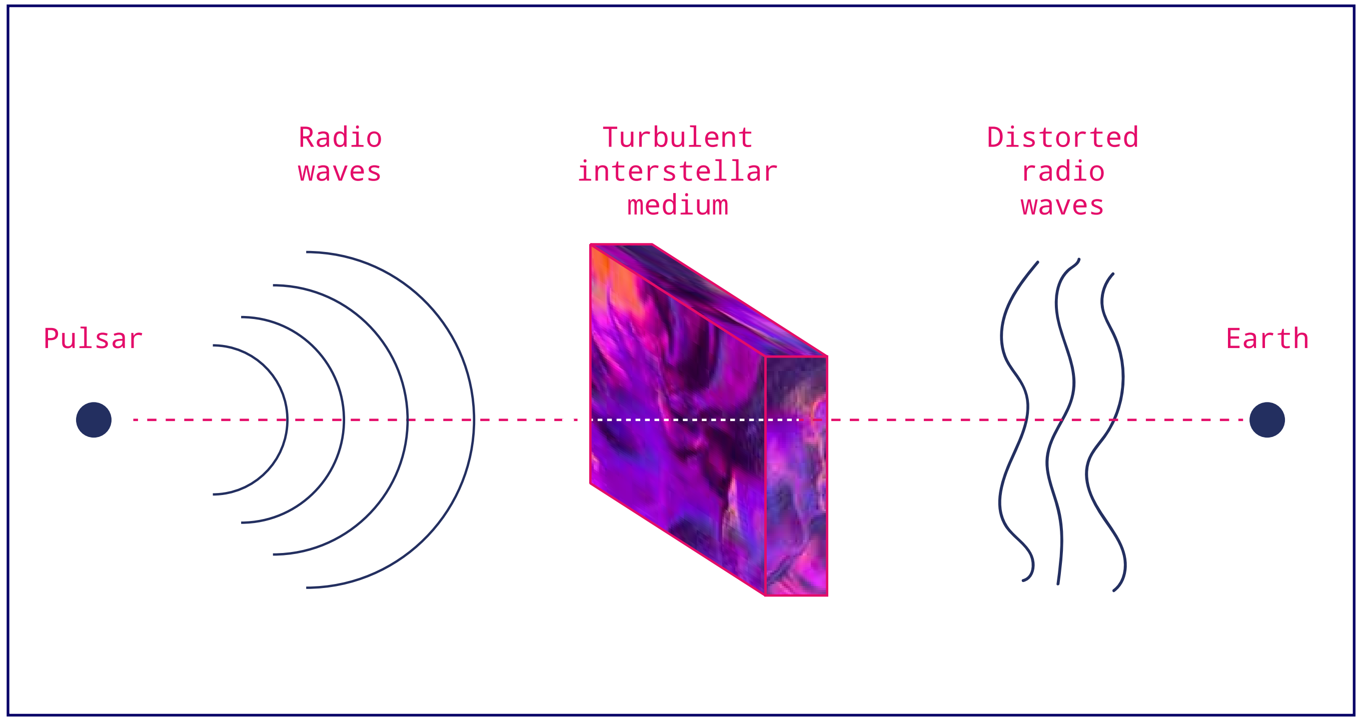
This is known as conservation of angular momentum: the star was rotating, and therefore its remnant also rotates, only faster because its mass is now compacted more tightly.

Spinning, fast and slow

Pulsars don't all spin at the same speed, in fact they vary quite greatly. The fastest are known as millisecond pulsars, and the quickest of those that we know of rotates a dizzying 716 times per second. Known as PSR J1748-2446ad (pulsars are named using their astronomical coordinates), it was discovered by Prof. Jason Hessels, co-chair of the SKAO's Transients Science Working Group.

In pulsar science, as in life, timing is everything. Millisecond pulsars can be used to form pulsar timing arrays, which are effectively galactic observatories. By finding millisecond pulsars in our galaxy, and timing the arrival of their pulses with exceptional precision, radio telescopes can detect any tiny shifts in those timings which are caused when gravitational waves distort time as they pass through the galaxy (read more about that in Contact issue 5).

Pulsar timing arrays are designed to detect the low-frequency gravitational wave background, the background waves thought to be caused by the slow merging of supermassive black holes (rather than the higher frequency waves caused by the violent collisions of less massive bodies, which are detected by other bespoke instruments either in space or here on Earth). A major breakthrough in 2023 saw multiple pulsar timing array projects worldwide unite to find the first evidence for these low-frequency waves.



The turbulence of the interstellar medium distorts the radio waves from a pulsar as they travel towards Earth.

At the other end of the activity spectrum to millisecond pulsars, the slowest known pulsar was detected in 2022, taking a leisurely 76 seconds to rotate. This begs the question: why do they have such different spin speeds? It depends on what phase of its existence the pulsar is in, and on its environment.

“As a pulsar rotates, the kinetic energy for it to spin is converted to the radio waves emitted, causing it to gradually lose energy and slow down, which we call ‘spin down rate’,” Harry says. “This isn’t necessarily a one-way street though; some pulsars may be powered up again by a companion star that feeds matter into the pulsar to make it spin faster! It’s thought that many millisecond pulsars are actually very old, having been sped up in this way.”

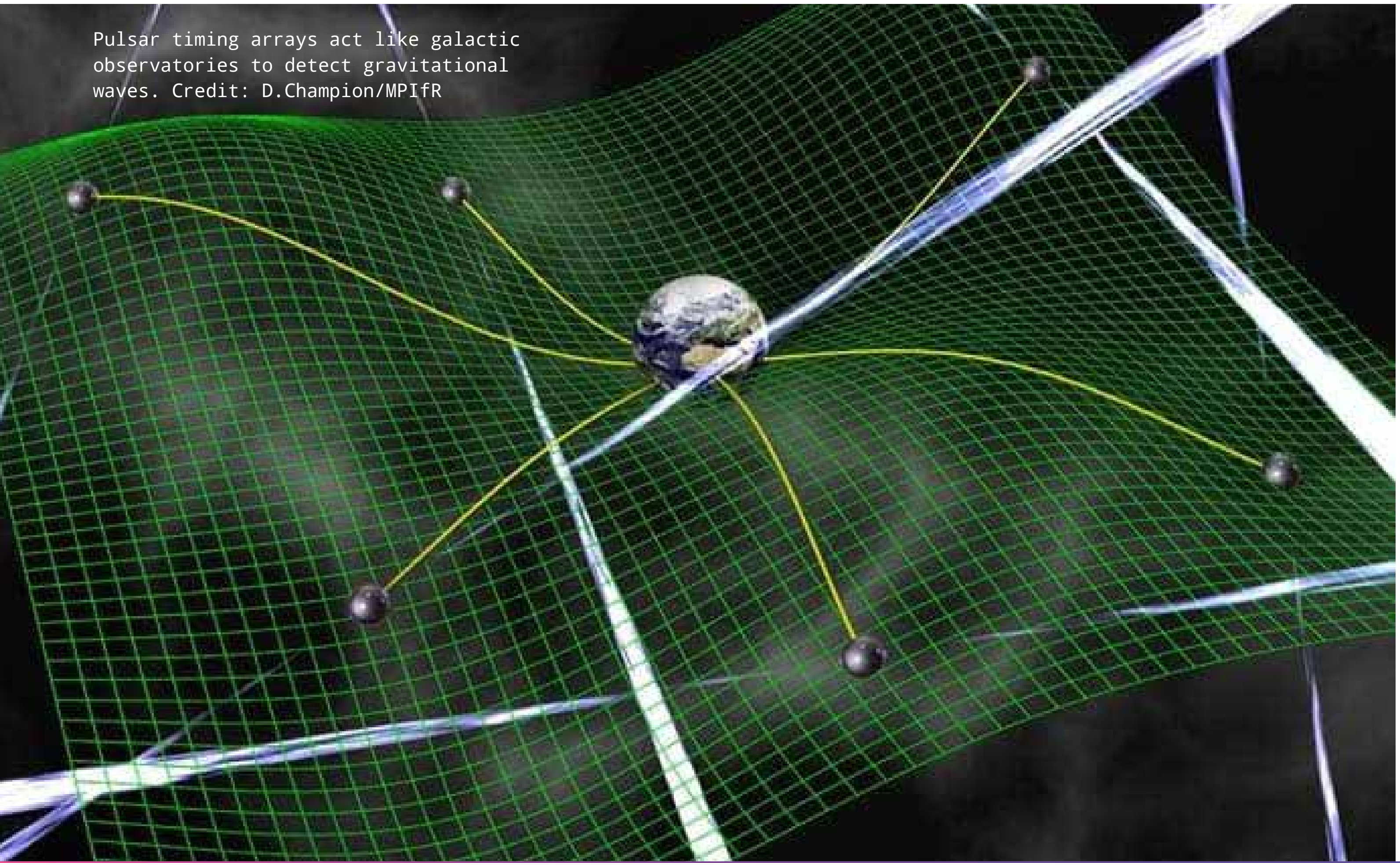
For those without such invigorating companions, the loss of spin is basically a death spiral. If a pulsar slows down too much, radio waves are no longer emitted, and the lighthouse beam goes out – this is known as the death line. When a pulsar’s spin rate falls below the death line, it is generally no longer detectable by radio telescopes. There are a few rare cases of pulsars emitting radio waves despite spinning at a very slow rate, below the death line, including the one with a 76-second rotation mentioned earlier. It’s thought a different emission mechanism could be at play here.

Pulsars’ spin-down rate is measured over millions of years. Over shorter time frames they are generally considered highly stable, often being compared to the most accurate atomic clocks on Earth. They do, however, sometimes exhibit erratic behaviour.

Even some of the most stable pulsars are known to “glitch”, where the rotation speed suddenly quickens, then gradually returns to normal over months or years. Glitches are thought to be caused by physical processes taking place within the pulsar. There are other behaviours which also point to pulsars being, as Harry puts it, “quite funky”.

“Some pulsars are also known to have two or more different modes of emission, for example emitting bright sporadic wide pulses and then turning off into a fainter weaker mode, all while maintaining the same rotation period. Others exhibit ‘nulling’, where they cease their emission altogether. We don’t fully understand why these things happen yet.”

“There are also some very unusual pulsars called magnetars which seem to be powered directly by their extremely strong magnetic fields – which are around 1,000 times stronger than regular pulsars – instead of being rotation powered!” Harry says. “We need to study them more to understand the underlying emission mechanisms.”



Pulsar timing arrays act like galactic observatories to detect gravitational waves. Credit: D.Champion/MPIfR

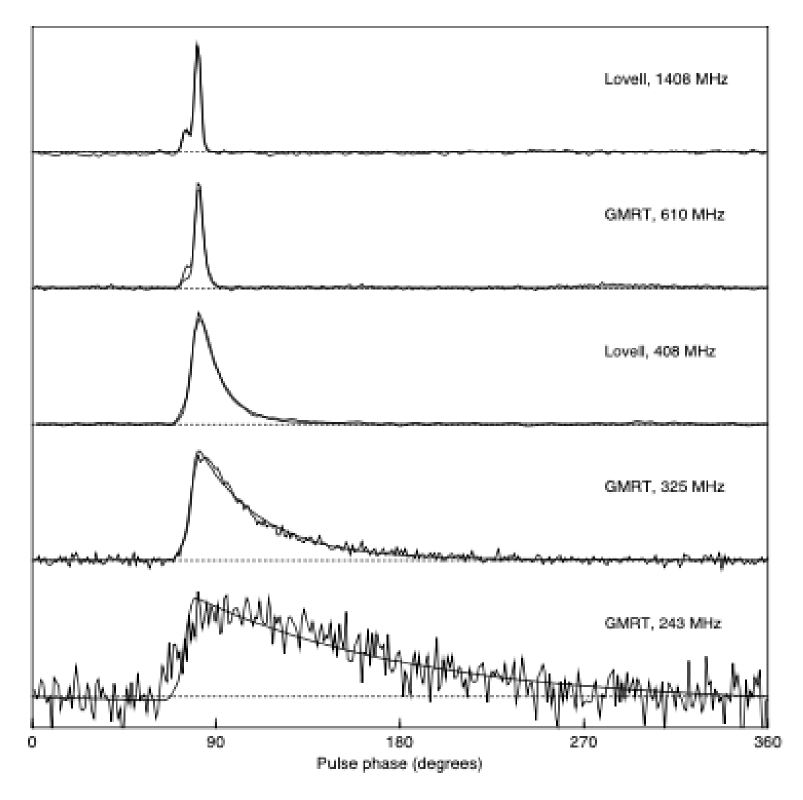
Probes of interstellar space

As well as pulsars being interesting in their own right, their radio signals are also useful vessels of information gathered on their journey towards Earth.

A pulsar’s radio signal covers a range of frequencies (unlike neutral hydrogen, for example, which emits at one specific frequency), and light/radio waves at different frequencies are affected differently by the environment.

“As the signal travels through the interstellar medium, it’s like going through glass – the radio waves get slowed down by different amounts at different frequencies. We describe the amount of delay as a dispersion measure, and it tells us how thick the interstellar medium the pulse has travelled through is,” Harry says. “If the interstellar medium is also very turbulent, or ‘clumpy’, the radio waves from the pulsar are scattered through different paths and are delayed at different rates, where at lower frequencies the delay difference is much greater, so astronomers see a pulse that looks different, with a broadened ‘tail’.

“You can think of a pulsar’s radio waves as being like a beam of light. They allow us to probe the interstellar medium of our galaxy just like using a laser beam to study the properties of a material,” Harry says. “We can use the signals to measure magnetic environments, because as they travel through magnetic fields a process called Faraday rotation takes place which ‘twists’ the radio waves. Measuring that rotation means we can measure the strength of the magnetic field.”



Above: What astronomers see: this pulsar observation, using the GMRT and Lovell radio telescopes, shows the effects of “scattering”, where radio waves at lower frequencies appear broader. The effect of turbulence in the interstellar medium causes radio waves emitted at the same time from the pulsar to scatter across different paths, causing them to arrive at different times on Earth. Credit: Oliver Löhmer

Pulsars in the SKAO era

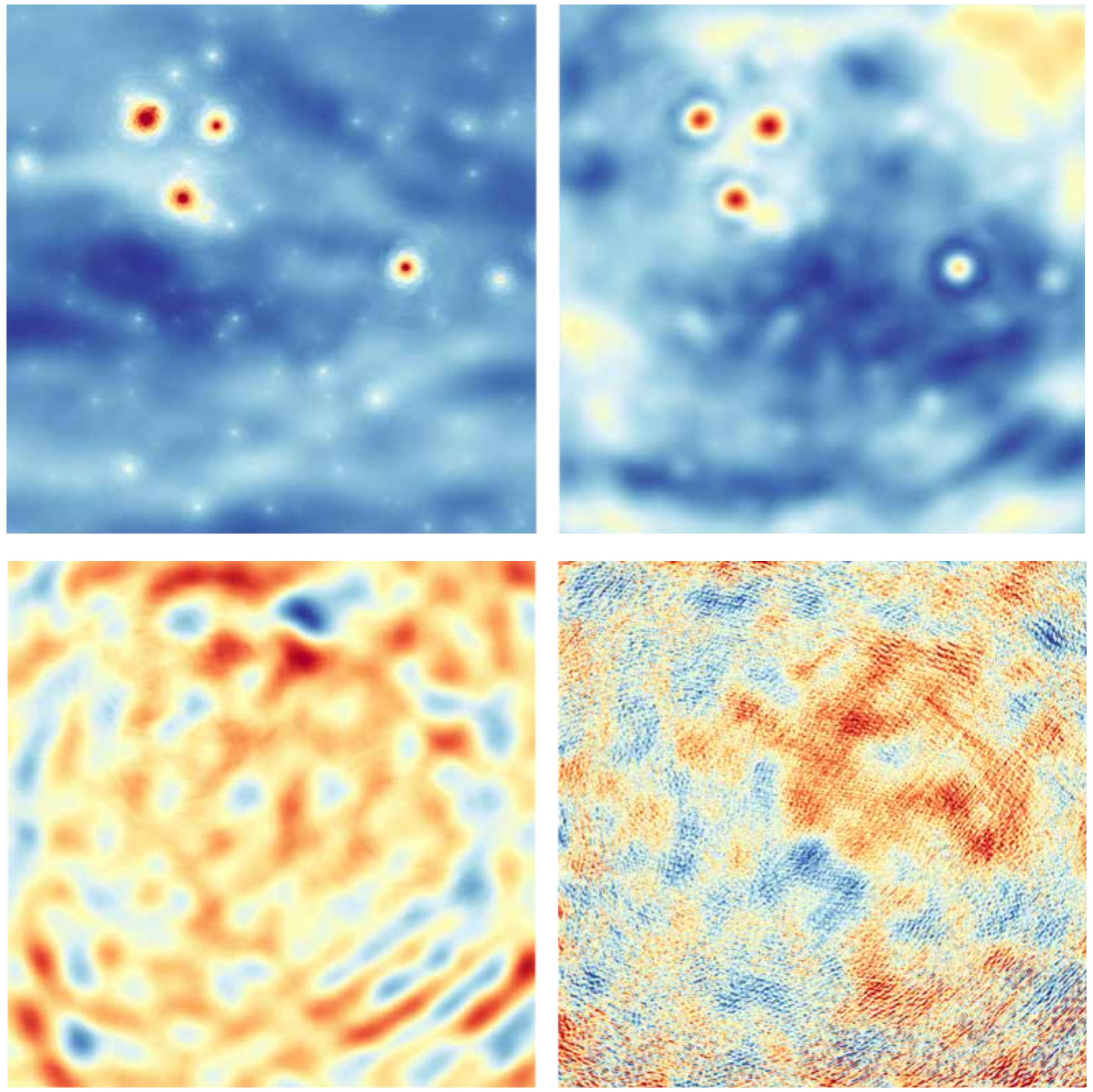
For radio studies of pulsars, the equation is quite simple: higher telescope sensitivity = better timing precision. The SKA telescopes will have much higher sensitivity than existing instruments, because the telescopes’ collecting area will be much greater owing to the sheer number of antennas. This means they will be able to time a pulse’s arrival to better than 100-nanoseconds accuracy – that’s 10 millionths of a second!

“That level of accuracy for pulsar timing is really unprecedented. Pulsar timing arrays are already in use of course, including the major MeerTIME project using the MeerKAT radio telescope, so we will be able to build on that and take things up a notch. By detecting the very faint signature of gravitational waves affecting radio signals coming from pulsars, we will be able to prove beyond doubt the existence of the elusive low-frequency gravitational wave background, and confirm its origin,” says Harry.

Astronomers also want to use the telescopes’ pulsar capabilities to test Einstein’s theories of gravity in the most extreme environment: around a black hole, where the strength of gravity causes space-time to become highly warped. Einstein made predictions about the nature of black holes and how such extreme gravity would delay light travelling through space.

Harry said: “If we can find a pulsar orbiting a black hole, we can use the SKA telescopes to time the pulses’ arrival with exceptional precision to see if our observations match what Einstein predicted. If they do, then Einstein was correct, but if not then that means that our current understanding of gravity doesn’t apply to these extreme environments. We’d be moving into the unknown, and that’s a really exciting prospect!”

With thanks to Dr Maciej Serylak, SKAO Deputy System Scientist, Architecture, for additional contributions.



The top-scoring team uncovered the underlying signal representing the era of the first stars (bottom right) by iteratively processing and removing layers of "foregrounds" that result from emission from our own and other galaxies. Credit: Dr Le Zhang, Sun Yat-Sen University.

Innovation on display in third SKAO Science Data Challenge

BY CASSANDRA CAVALLARO (SKAO)

"Our efforts to prepare the science community for dealing with the immense challenge of SKA data are paying off."

That was the verdict of SKAO Senior Scientist Dr Anna Bonaldi following the conclusion of the Observatory's third Science Data Challenge, which ran from March to November 2023.

Work is now underway to document and study the teams' different approaches, in order to identify the most effective methods to analyse the huge swathes of data that will flow from SKA telescopes.

The volume of data that will be generated demands a step change in how astronomers conduct their research; the challenges are designed to support them as they prepare for this shift.

With 234 registered participants spread across 33 teams and 16 countries, this third challenge brought together astronomers, data scientists, software engineers and other specialisms, demonstrating the enthusiasm and diversity intrinsic to the SKA science community.

Twelve supercomputing centres around the world provided resources for participants to deploy their data processing pipelines, including SKA Regional Centre prototypes.

Taking the top spots on the scoreboard were the HIMALAYA team based in China, closely followed by the DOTSS-21cm team which has members in five countries.

The challenge

Teams were tasked with analysing a 7.5 TB data set made up of layer upon layer of simulated astronomical data, going back billions of years through cosmic time, in order to extract one of the faintest signals in astronomy: the light from the Epoch of Reionisation (EoR). This was when the Universe transitioned from the so-called dark ages, to when the first stars and galaxies formed.

"The signal has never been detected in reality, but the SKA telescopes' size and sensitivity, coupled with modern computing, will give the best hope yet of achieving this key science goal," said Dr Bonaldi, co-lead of the challenge.

If observed from Earth, the signal is obscured by everything in between us and it: the light from other galaxies and emission from within our own galaxy in the foreground. The teams had to work out how to most effectively remove this foreground emission in order to identify the EoR signal.

"To recover the simulated EoR signal from all this other 'noise' is very challenging. The foreground contamination is about 100,000 times brighter than the EoR signal, and we also included realistic instrumental effects, where the telescope itself introduces errors on the image, particularly affecting small details which it can't see very well.

"We weren't sure the teams would succeed within the constrained timeframe, but we are delighted that several of them produced a very good result. HIMALAYA did this using a very ingenious, almost counterintuitive approach."

Discarding data

The top-scoring team was led by Dr Le Zhang, based at Sun Yat-Sen University in Guangzhou, who was supported by colleagues at Shanghai Astronomical Observatory.

"You can try to recover the EoR signal with all the small details, but this can compromise the image if it's not done perfectly," explained Dr Zhang.

"Instead, we actually lowered the resolution of the image even further. This process, called reconvolution, throws away part of the information, but reduces errors in the information that you keep. In this case it meant each pixel on the sky was much cleaner and easier to model to address the removal of the foreground contamination."

The second-placed DOTSS-21cm team used a recently developed technique they pioneered on EoR and Cosmic Dawn studies using SKA pathfinders LOFAR and NenuFAR. This involved first pinpointing and removing bright, distant galaxies, then removing the bright but more diffuse emissions from the Milky Way.

"Lastly, we faced a 'confusion noise' stage, where fainter foreground sources blur together. To separate the even fainter 21-cm signal from these, we used a machine learning technique called ML-GPR, supported by a dedicated and powerful computer cluster," said team leader Dr Florent Mertens, based at Paris Observatory's LERMA institute.

"This method utilises machine learning algorithms to understand the statistical characteristics of the 21-cm signal from an extensive set of simulations.

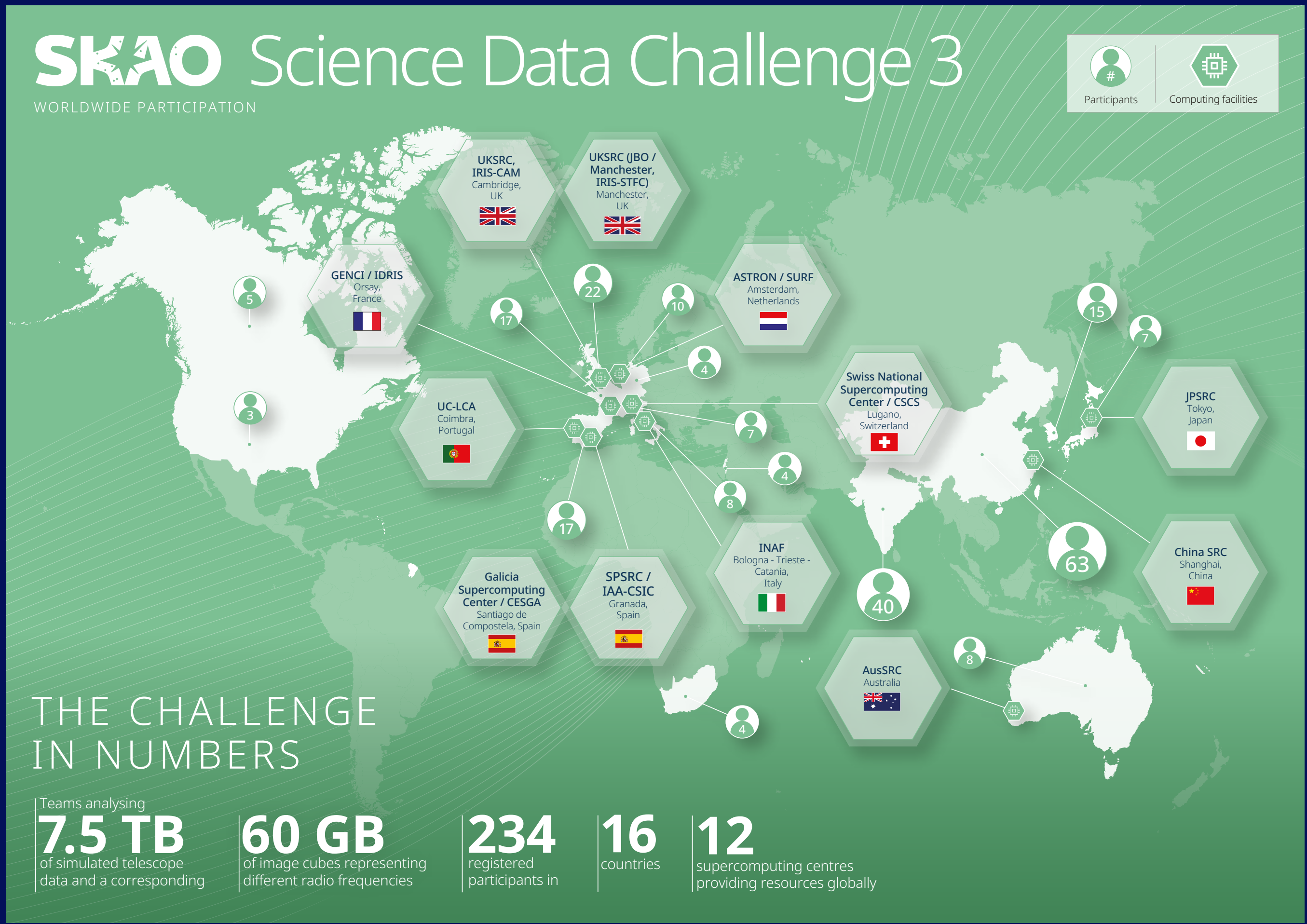
It allows for a more robust and accurate separation of the signal, distinguishing it from the overwhelming dominant foreground emission."

For SKAO Science Director Dr Robert Braun, the teams' results provide a solid foundation for analysing real SKA observations.

"I'm thrilled to see these results; I had some concerns when we issued this challenge that it might prove impossible to recover these faint simulated signals," Dr Braun said. "I am now very hopeful that the collaborative refinement of signal recovery techniques within our global community will allow the actual EoR signal to be detected with confidence."

"The signal has never been detected in reality, but the SKA telescopes' size and sensitivity, coupled with modern computing, will give the best hope yet of achieving this key science goal."

DR ANNA BONALDI, SKAO SENIOR SCIENTIST



Pooling expertise

Although teams were scored to determine the effectiveness of the techniques, the challenges are not designed to be competitive. Instead, their value is in testing out different approaches and learning from each other in order to find the best method or combination of methods.

"This was my first encounter with simulated SKA data. I found the data format user-friendly, which makes it easy to work with, and now I intend to thoroughly study the programs and algorithms employed by other teams," Dr Zhang said. "This collaborative effort will encourage shared learning, the exchange of interesting ideas, and the advancement of data analysis and algorithms for SKA EoR measurements."

The DOTSS-21cm team, which included specialists in radio astronomy, signal processing, computer science, and 21-cm signal and foreground simulations, found similar value in taking part.

"The challenge was incredibly exciting and insightful for us, and by bringing together experts from different countries, we've been able to pool a wide range of skills and knowledge. Tackling the specific challenges of this dataset gave us the opportunity to refine our methods and think about new approaches to data analysis," said Dr Mertens.

> "This collaborative effort will encourage shared learning, the exchange of interesting ideas, and the advancement of data analysis and algorithms for SKA EoR measurements."
>
> DR LE ZHANG, HIMALAYA TEAM LEADER

The challenge has also had broader impacts; the UK-based Nottingham-Imperial team used it to train two new PhD students at Imperial College and Nottingham University.

"It was a great way to give them a crash course on the intricacies of radio data and the various methods used to transform the data from the raw, messy observations to the lovely clean images we want," said team leader Dr Emma Chapman. "It added some spark to what otherwise may have been a standard reading/coding exercise, and we all learned a lot, including us as supervisors!"

In Australia, the Wizards of Oz 3D team used the challenge to analyse techniques designed for the Murchison Widefield Array, an SKA precursor telescope which is studying the distant Universe.

"We gained value from needing to adjust components of our MWA pipeline for the SKA dataset," says team spokesperson Dr Cathryn Trott. "This exposed parts that hadn't been looked at for a while, and so we were able to re-visit those in our codebase and take a fresh view of how they were functioning."

Open science

Importantly, the data challenges put into action the SKAO's commitment to open science, through encouraging teams to publish their code so that others can reproduce their results.

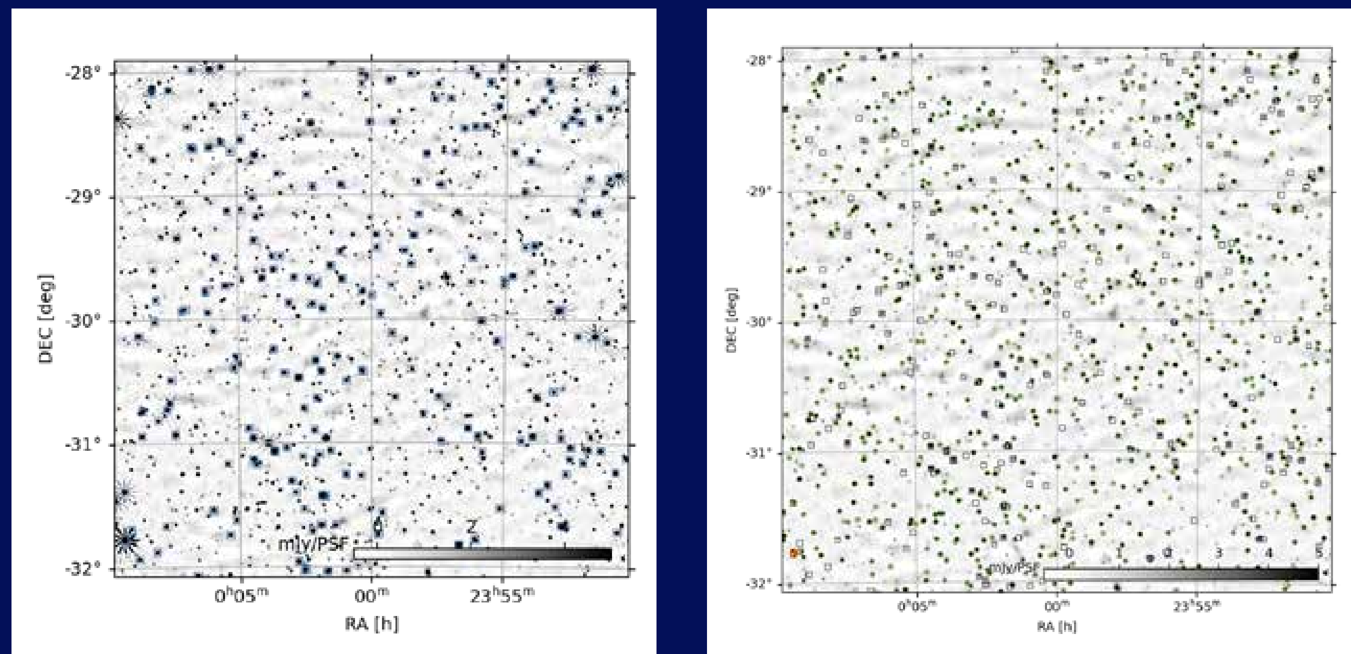
"We wanted to recognise teams' efforts in this area through 'reproducibility badges' for those who published their data pipelines. Nine teams have earned these badges, which is a clear show of support for the goals of open science: making science more accessible and by extension more widely beneficial," said SKAO Scientist Dr Philippa Hartley, co-lead of the challenge.

"These algorithms are extremely powerful when dealing with mammoth data sets, so they could well be adapted for other purposes in the future - that's why open science is so important."

The next challenge, which opened for registrations in March, will ask teams to establish important parameters of the Epoch of Reionisation. They'll be using simulations to determine the fraction of hydrogen gas that became ionised over time, which can help to infer how many stars there were, and when they started forming.

"We're hoping that teams will use this next stage of the challenge to expand on what we've learned from this one, but what we've already seen is that, in terms of the community maximising the potential of SKA data, we're in very good hands," says Dr Bonaldi.

"So far, they have risen to meet the challenge with great ingenuity, and I am excited to see what they come up with next."



The DOTSS-21cm team's point-source detection steps. In the first step (left), bright compact sources were detected (highlighted in blue squares); in the second step (right), these have been subtracted from the image, and fainter compact sources have been detected (highlighted in green circles). Credit: Florent Mertens/DOTSS-21cm team

The AAVS3 demonstrator was installed in 2023 Credit: SKAO

First light for SKA prototype antennas

BY THE SKAO AND MAX PLANCK INSTITUTE FOR RADIO ASTRONOMY

As construction on the SKA telescopes continues apace, prototype instruments have been reaching their own milestones: achieving "first light". Technology demonstrators in Australia and South Africa are being used to test systems and help the SKAO to prepare for commissioning of the full-scale telescopes in the coming years.

In January, the first prototype dish of the SKA-Mid telescope constructed on site in South Africa created its first image.

The prototype, assembled in mid-2018, is a fully functioning single-dish radio telescope in its own right, funded by Germany's Max Planck Society for technical commissioning and scientific use. Known as SKAMPI, it was designed by the SKAO's international Dish consortium, involving institutions in 10 countries and led by CETC54 in China, where it was also manufactured.

SKAMPI's first light image of the Southern Sky at 2.5 GHz wavelength demonstrates that the technology is working as expected, and although the uncalibrated measurements are still affected by radio frequency interference (RFI), atmospheric and system variations, the image already reveals much of the characteristic radio emission of our Milky Way and external galaxies such as Centaurus A. The team also tested out the dish's pulsar mode, detecting the Vela pulsar.

"Tests of the SKAMPI prototype have already provided invaluable measurements of key performance parameters. These have been used to refine the design of the SKA-Mid dishes to ensure that they meet our demanding requirements for pointing and surface accuracy," said SKAO Head of System Science Dr Robert Laing. "The test procedures developed for SKAMPI will also be used to qualify the new SKA-Mid dishes before they are integrated into the array."

SKAMPI will enter full science operations later this year, with further technical developments planned. Although much of its observing time will be dedicated to science programmes defined by the SKAMPI team, requests for observations will also be open to the South African and German science communities, and setting up an educational programme for schools and universities is under consideration.

A couple of months earlier on the other side of the Indian ocean, the SKA-Low technology demonstrator Aperture Array Verification System 3 (AAVS3) also achieved first light.

Comprising one full station of 256 SKA-Low antennas, it is designed to verify that performance, cost, and schedule are maintained on SKA-Low's eventual 131,072 antennas. The demonstrator is located at Inyarrimanha Ilgari Bundara, the CSIRO Murchison Radio-astronomy Observatory, where SKA-Low is now under construction.

AAVS3 uses the fourth generation of SKA-Low antenna design, optimised by the Italian National Institute for Astrophysics (INAF) in collaboration with CNR-IEIIT and the Italian industrial partner SIRIO Antenne, building on previous designs developed within an international consortium involving six countries.

It uses a different layout to previous demonstrator stations, and has helped to determine the optimal configuration to minimise interference between the antennas.

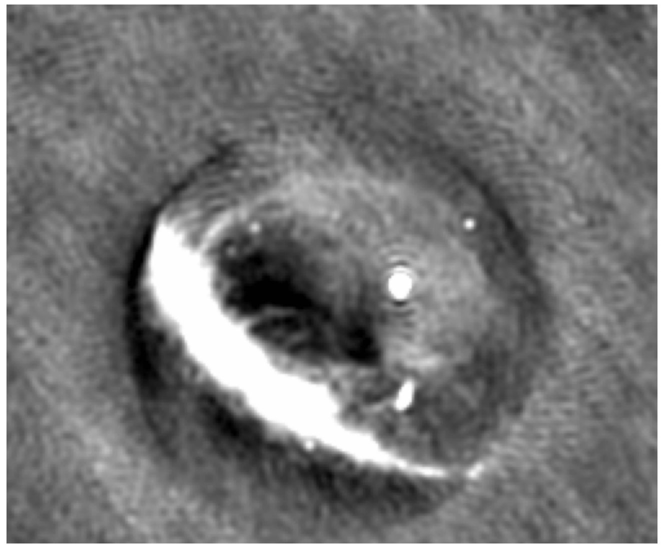
One week after a test readiness review, the Assembly Integration and Verification (AIV) and Operations team captured 45 minutes of data with AAVS3 during the Sun's transit.

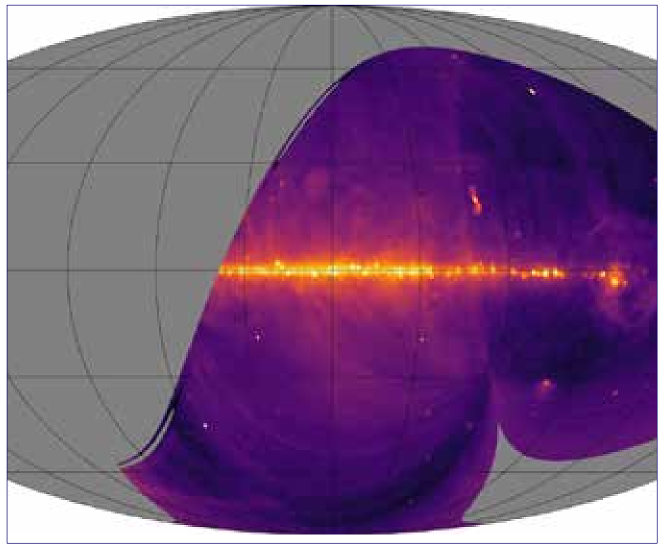
Associate Prof. Randall Wayth from Curtin University calibrated and imaged the data. The arcing pale band of the Milky Way's galactic plane is clearly visible, with the brighter spots of the Centaurus A galaxy and our Sun on the right of the picture.

"It is incredible to see how 256 antennas with less than 40 m of baseline have managed to capture so many details of the full sky. I found this pretty remarkable, and it is extremely encouraging for the performance of the full array," said SKA-Low Station Integration Engineer Marco Caiazzo.

"The significance of this image is the validation that the station is working as expected. This will help to accelerate the verification program in preparation for AA0.5, the first stage of SKA-Low telescope delivery."

SKAMPI was fully assembled in mid-2018 at the South African SKA site in the Karoo by the Max Planck Institute for Radio Astronomy (MPIfR), OHB Digital Connect GmbH and the South African Radio Astronomy Observatory (SARAO)





Left: The first image from AAVS3 shows the arcing pale band of the Milky Way's galactic plane, with the brighter spots of the Centaurus A galaxy and our Sun on the right of the picture. Credit: SKAO

Right: First light SKAMPI image of the Southern Sky at 2.5 GHz wavelength. The frame (in grey) shows the complete sky in galactic coordinates with the Galactic centre in the middle. The false colour image shows radio emission from the part of the sky which is accessible to the telescope in South Africa. Besides radio emission from the Galactic centre (Sgr A), the bright radio galaxy Cen A, both Magellanic clouds and star forming areas in Orion and Vela show up in the image. Credit: SKAMPI Team

MeerKAT uncovers a mysterious object at the boundary between black holes and neutron stars

BY DR EWAN BARR AND ARUNIMA DUTTA (MAX PLANCK INSTITUTE FOR RADIO ASTRONOMY)

An international team of astronomers has discovered an intriguing object which is heavier than the heaviest known neutron stars – and yet simultaneously lighter than the lightest black holes known – in orbit around a rapidly spinning millisecond pulsar.

This could be the first discovery of the much-coveted radio pulsar-black hole binary, a stellar pairing that would allow new tests of Einstein's general relativity.

The research, published in the journal Science, was led by researchers from Germany's Max Planck Institute for Radio Astronomy, as part of the international Transients and Pulsars with MeerKAT (TRAPUM) collaboration.

Neutron stars, the ultra-dense remains of a supernova explosion, can only be so heavy. Once they've acquired too much mass, they will collapse, and the prevailing opinion is that they then become black holes. Theory, backed by observation, tells us that the lightest black holes that can be created by collapsing stars are about five times more massive than the Sun. This is considerably larger than the 2.2 times the mass of the Sun required for neutron star collapse, giving rise to what is known as the black hole mass-gap. The nature of compact objects in this mass gap is unknown and detailed study has thus far proved challenging due to only fleeting glimpses of such objects being caught in observations of gravitational wave merger events in the distant universe.

The team observed a massive pair of compact stars in the globular cluster NGC 1851, within our own galaxy in the southern constellation Columba. They detected faint pulses from one of the stars, identifying it as a radio pulsar, a type of neutron star that spins rapidly and shines beams of radio light into the Universe like a cosmic lighthouse.

This pulsar spins more than 170 times a second, with every rotation producing a rhythmic pulse, like the ticking of a clock. By observing small changes in this ticking over time, using a technique called pulsar timing, they were able to make extremely precise measurements of its orbital motion.

The regular timing also allowed a very precise measurement of the system's location, showing that the object in orbit with the pulsar was no regular star – it is invisible in Hubble Space Telescope images of NGC 1851 – and is in fact an extremely dense remnant of a collapsed star. Furthermore, the observed change with time of the closest point of approach between the two stars (the periastron) showed that the companion has a mass that was simultaneously bigger than that of any known neutron star and yet smaller than that of any known black hole, placing it squarely in the black-hole mass gap.

"Whatever this object is, it is exciting news", says Dr Paulo Freire, of the MPIfR. "If it is a black hole, it will be the first pulsar-black hole system known, which has been a Holy Grail of pulsar astronomy for decades! If it is a neutron star, this will have fundamental implications for our understanding of the unknown state of matter at these incredible densities."

Right: An artist's impression of the newly discovered system, assuming that the massive companion of the radio pulsar (bright blue star in the background) is a black hole (foreground). Both objects are eight million kilometres apart and orbit each other every seven days.

Observations of dramatic galactic collision unlock clues to the reionisation of the Universe

SOURCE: STOCKHOLM UNIVERSITY AND THE OSKAR KLEIN CENTRE

A study using the MeerKAT radio telescope has revealed how galaxy mergers might have influenced the transformation of the Universe during the Epoch of Reionisation (EoR), a crucial period which began around 400 million years after the Big Bang. The work has been published in the Monthly Notices of the Royal Astronomical Society.

An international team led by Dr Alexandra Le Reste from Stockholm University and the Oskar Klein Centre, observed the neutral hydrogen in a galaxy emitting strong ultraviolet radiation for the first time. Dr Le Reste is a member of the SKAO's HI Science Working Group.

During the EoR the neutral hydrogen gas that filled the Universe became fully ionised. Ionisation happens when neutral hydrogen encounters strong ultraviolet radiation. While it is widely accepted that the first galaxies were the main source of this ultraviolet radiation, it is not fully known how the ultraviolet rays managed to escape the galaxies to ionise the Universe as a whole.

Galaxies themselves contain a large amount of neutral hydrogen which prevents the strong ultraviolet rays from stars from escaping galaxies, similar to the way the atmosphere around the Earth absorbs the energetic ultraviolet radiation from the Sun and prevents it from reaching us. Understanding how this escape happened is therefore crucial to test models for reionisation and for the evolution of the Universe. The issue was that no one had ever mapped the neutral hydrogen gas in a galaxy emitting strong ultraviolet radiation directly.

The galaxy Haro 11, about 300 million light years away from Earth, is the closest and one of only three galaxies in the nearby Universe that is known to emit strong ultraviolet radiation capable of ionising hydrogen.

In galaxies forming stars, the neutral hydrogen gas is typically located all around the galaxy and its stars in a relatively symmetrical manner. What MeerKAT's sensitivity has revealed for the first time is the highly unusual distribution of hydrogen around Haro 11: almost all the gas is on one side of the galaxy, far away from its stars.

Astronomers already knew Haro 11 was formed in a collision between two galaxies, but they did not expect that the collision has had such a dramatic effect on the gas. When the two original galaxies merged, the gravitational forces pulled the gas away and exposed the regions that produce ultraviolet radiation.

This discovery unveils a previously unknown factor: the effect of galaxy mergers on pulling the gas far away from galaxies, which could help the ultraviolet radiation to escape more easily from stars in these galaxies. It is an important addition to our understanding of how galaxies participated in the reionisation of the Universe.

"Galaxies formed in a hierarchical manner, with smaller galaxies merging into bigger ones under the effect of gravitation as the Universe evolved. For this reason, it is expected that galaxy mergers, or collisions, were much more common in the past than they are nowadays," said Dr Le Reste, who led the study as part of her doctoral thesis.

"It is not unreasonable to think that the mechanism we identified, with the gas being ejected far from the centre of galaxies during galaxy mergers, could play an important role during the Epoch of Reionisation."

In the future, the SKA telescopes will not only allow many sources with faint gas to be observed in great detail, but will also image the gas in the intergalactic medium during the Epoch of Reionisation itself.

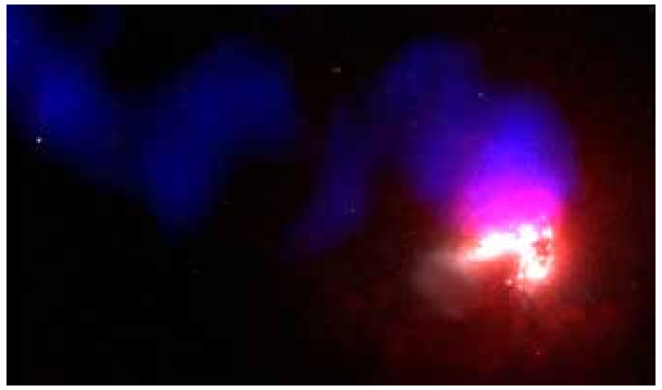


Image of the galaxy Haro 11. Stars, shown in white, are surrounded by a halo of ionised gas in red. The newly imaged neutral Hydrogen gas, in blue, has been displaced during an interaction between two galaxies that resulted in the creation of Haro 11. Credit: Le Reste et. al.

MeerKAT marks fifth anniversary with conference and expansion

BY SARAO COMMUNICATIONS

Since its inauguration in 2018, South Africa's MeerKAT radio telescope has been going from strength to strength. February saw scientists, researchers, and policy makers that have been involved in the development and scientific exploitation of MeerKAT gather for an international conference celebrating its successes. The same week saw the handover of the first dish in the telescope's extension project called MeerKAT+.

The MeerKAT@5 conference was held at Stellenbosch Institute for Advanced Study near Cape Town from 20-23 February, and brought together key stakeholders who have contributed to the telescope's development. More than 150 abstracts were submitted and 250 participants attended from across Africa, Europe, the USA, and Asia.

"We are not only celebrating a technological marvel but also reflecting on the profound scientific discoveries and advancements it has enabled," Minister of Higher Education, Science and Innovation Dr Blade Nzimande said in his keynote address.

He also noted the positive impact investments in radio astronomy had on local towns such as Carnarvon, the town used as a gateway to the MeerKAT and SKA-Mid telescope site, highlighting such infrastructure developments including road construction, power networks, and telecommunication facilities to support the telescope's operations.

"These activities have encouraged community involvement, sparked interest in science among residents, and fostered a sense of pride in their local scientific achievements. The presence of MeerKAT has attracted visitors from around the world, including scientists, researchers, and tourists interested in astronomy," said Dr Nzimande.

The conference coincided with the handover of the first MeerKAT+ antenna on 21 February, marked by a ceremony in the Karoo. It is the first of 14 antennas of the MeerKAT extension project, which is being jointly financed by Germany's Max Planck Society, SARAO and Italy's National Institute of Astrophysics. The MeerKAT extension will be integrated, along with the existing 64 MeerKAT dishes, into the SKA-Mid telescope in the future.

The expansion of the MeerKAT telescope will further deepen the scientific and technological cooperation that has already begun through the close collaboration between SARAO and its international partners as part of MeerKAT.

"The project only started in 2019 and it is great to see that the first successes of this joint project are now visible," said SARAO Managing Director Pontsho Maruping. "The MeerKAT+ expansion project will significantly improve the sensitivity, angular resolution and image quality of the MeerKAT radio telescope."

The expansion of MeerKAT increases the sensitivity of the receiving systems by around 50%, enabling not only much faster mapping of the sky but also the detection of extremely weak astronomical sources.

Top: The first MeerKAT+ antenna at the South African SKA site in the Karoo. Credit: MPIfR / Gundolf Wieching

ASKAP maps sky for the world

BY RACHEL RAYNER (CSIRO)

The Rapid ASKAP Continuum Surveys (RACS) map the sky using CSIRO's ASKAP radio telescope, with the data made available to all researchers. The surveys in the low and mid-frequency range have now been completed, with the high-frequency data expected in the next few months.

These detailed maps of the radio sky can be added to other data from optical, gamma, infrared or x-ray telescopes to gain a complete image of our Universe.

The RACS project is conducted and delivered by the ASKAP team at CSIRO, Australia's national science agency. It is designed to deliver data-rich sky maps whilst also improving telescope operations.

It is a chance for the CSIRO research team to experiment and realise ASKAP's potential. The aim was to very quickly create a world-class catalogue of as many radio objects as are visible in the southern sky: a thorough and simultaneous test of the telescope's abilities in speed, sensitivity and resolution.

Situated at Inyarrimanha Ilgari Bundara, the CSIRO Murchison Radio-astronomy Observatory on Wajarri Yamaji Country in Australia, ASKAP is CSIRO's newest and most advanced radio telescope. As one of the SKA precursor telescopes, it is paving the way for some of the technology and innovation needed for the SKA telescopes, including experience gained in delivering the RACS project.

The first RACS was done in ASKAP's lower frequency range (RACS-low) and though it was experimental, the resulting science output was state-of-the-art and demonstrated early on that ASKAP is a revolutionary survey telescope. Within 300 hours, it succeeded in producing data on three million galaxies.

Even so, improvements were made to the observing and processing strategies, as well as adding higher frequency band surveys. Observing at different frequency bands is similar to providing extra colours in optical surveys and allows for a better understanding of the physics of a detected object.

Now, ASKAP has mapped the sky to produce more resources for astronomers: RACS-mid and the impressive RACS-low3. RACS-low3 is a further improvement on previous RACS-low surveys, with ASKAP achieving increased sky coverage and improved sensitivity. Early results indicate that about four million sources have been captured.

The data is freely available to all researchers on CASDA, the CSIRO ASKAP Science Data Archive. The team is currently working on RACS-high (ASKAP's highest frequency range) and aims to have the whole survey available very soon.

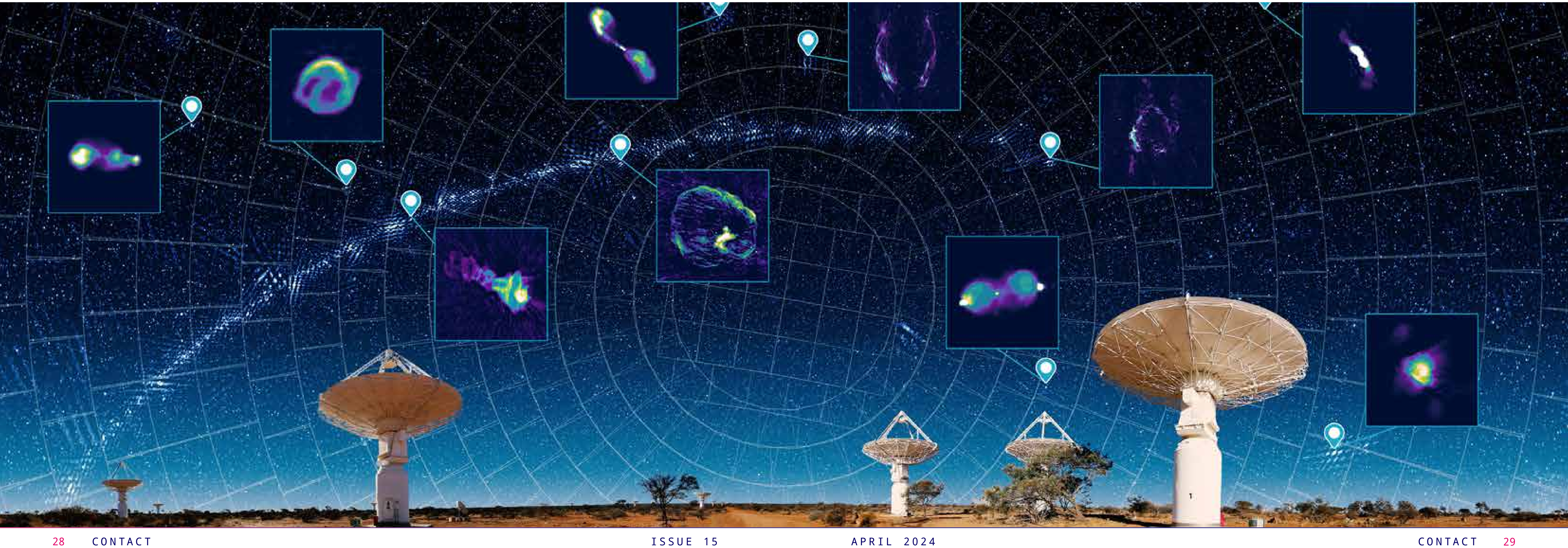
The next and most exciting research will be to combine all the frequency ranges into one RACS. With so much data – so many different "colours" – there's sure to be some surprises that come to light!

For updates and to find out more about ASKAP's RACS, [visit the website here](#).

CSIRO acknowledges the Wajarri Yamaji as Traditional Owners and native title holders of Inyarrimanha Ilgari Bundara, the CSIRO Murchison Radio-astronomy Observatory site.

Above: An artwork by Wajarri Yamaji artist, Margaret Whitehurst, was commissioned to celebrate RACS. Copyright: Margaret Whitehurst, RACS, 2019

Below: Data from RACS with highlighted features, displayed above CSIRO's ASKAP radio telescope on Wajarri Country. Credit: Sam Moorfield and CSIRO



Murriyang, CSIRO's Parkes radio telescope. Credit: Alex Cherney and CSIRO

Murriyang's detection of magnetar reveals strange behaviours

BY RACHEL RAYNER (CSIRO)

Researchers using Murriyang, CSIRO's Parkes radio telescope – a pathfinder for the SKA telescopes – have detected unusual radio pulses from a previously dormant star with a powerful magnetic field.

New results published in Nature Astronomy describe r adio signals from magnetar XTE J1810-197 behaving in complex ways.

Magnetars are a type of neutron star and the most powerful magnets in the Universe. At roughly 8,000 light years away, this magnetar is also the closest known to Earth. Most are known to emit polarised light, though the light this magnetar is emitting is circularly polarised, where the light appears to spiral as it moves through space.

Dr Marcus Lower, a postdoctoral fellow at Australia's national science agency, CSIRO, led the latest research and said the results are unexpected and totally unprecedented.

"Unlike the radio signals we've seen from other magnetars, this one is emitting enormous amounts of rapidly changing circular polarisation. We had never seen anything like this before," Dr Lower said.

Dr Manisha Caleb from the University of Sydney is part of the SKAO Transients and Pulsars Science Working Groups, as well as a co-author on the study. She said studying magnetars offers insights into the physics of intense magnetic fields and the environments these create.

"The signals emitted from this magnetar imply that interactions at the surface of the star are more complex than previous theoretical explanations."

Detecting radio pulses from magnetars is already extremely rare: XTE J1810-197 is one of only a handful known to produce them. While it's not certain why this magnetar is behaving so differently, the team has an idea.

"Our results suggest there is a superheated plasma above the magnetar's magnetic pole, which is acting like a polarising filter," Dr Lower said. "How exactly the plasma is doing this is still to be determined."

XTE J1810-197 was first observed to emit radio signals in 2003. Then it went silent for well over a decade. The signals were again detected by the University of Manchester's 76-m Lovell telescope at the Jodrell Bank Observatory in 2018 and quickly followed up by Murriyang, which has been crucial to observing the magnetar's radio emissions ever since.

The 64-m diameter telescope on Wiradjuri Country is equipped with a cutting edge ultra-wide bandwidth receiver. The receiver was designed by CSIRO engineers who are world leaders in developing technologies for radio astronomy applications.

The receiver allows for more precise measurements of celestial objects, especially magnetars, as it is highly sensitive to changes in brightness and polarisation across a broad range of radio frequencies. The SKA-Mid telescope, when operational, is likely to detect many more magnetars than the handful currently known.

Studies of magnetars such as these provide insights into a range of extreme and unusual phenomena, such as plasma dynamics, bursts of X-rays and gamma-rays, and potentially fast radio bursts.

Team SKA: Prof. Yashwant Gupta

In January, India confirmed it will seek membership of the SKAO and committed funding for seven years of construction and operations. The news was music to the ears of those who have dedicated years of work to the SKA project in India on the science, software and engineering fronts.

Among those at the forefront of this effort has been Prof. Yashwant Gupta, director of India's National Centre for Radio Astrophysics (NCRA) in Pune, part of the Tata Institute of Fundamental Research.

A pulsar specialist and 2007 recipient of India's prestigious Shanti Swarup Bhatnagar Prize for Science and Technology, Yashwant has long been an important voice in the SKA project, having led the Telescope Manager engineering consortium through the crucial telescope design phase, and having served on the Board of Directors of the SKA Organisation, precursor to the Observatory. We spoke to him about pulsars, why India's membership of the SKAO is so beneficial, and how his childhood hobby became a successful career.

First of all, Yashwant, congratulations on the news that India has now signed the SKAO Convention and is now proceeding towards ratification to become a full member of the Observatory. What does that mean to you, having worked to achieve this for so many years?

Thank you! It is a major milestone for all of us in India who have been involved in SKA-related activities. It is very satisfying to see the effort of the last 10 years or so bringing us to this moment, which opens the doors fully for India to be part of this fantastic new global observatory.

It means we can go ahead full throttle with all the plans for India's contribution towards the SKAO's construction phase, as well as with plans for developing the required infrastructure and resources in India to prepare to do cutting edge science when the SKA telescopes are ready, including an SKA Regional Centre (SRC) in India. The SRCs will be a global network of computing centres that will process, store and provide access to SKAO data products for astronomers.

How do you see SKAO membership benefitting India?

The benefits are multifold. SKAO membership allows India to build upon its long tradition and expertise in radio astronomy and carry it over from domestic projects like the Giant Metrewave Radio Telescope (GMRT) to the international arena. It will also bring lots of benefits to Indian industry as we plan to make in-kind contributions in a range of areas covering radio frequency electronics, digital hardware and signal processing systems, data processing software and also monitoring and control software. The technological knowledge and experience of working in/for the SKAO will also benefit the growth of research and development activities in India, both in terms of existing radio astronomy facilities as well as in applications to other allied fields of research. Last, but not the least, it will allow the Indian astronomy community access to the best facility in low and mid-frequency radio astronomy in the world.

Let's turn to your own life now and rewind to your childhood growing up in India. Did you always dream of being an astrophysicist?

When I was in high school, I got interested in astronomy thanks to the astronomy hobby club in my school, and some encouragement from my father. From then on, my interest in astronomy kept growing, but it remained just as my favourite hobby. It was not until I completed my undergraduate degree in Electrical Engineering that I decided to make the shift towards a career in radio astronomy and astrophysics as a graduate student.

What was the education and career path that led you to the NCRA, and ultimately to the SKA project?

After my undergraduate degree at the Indian Institute of Technology in Kanpur, I moved over to a PhD in Radio Astrophysics at the University of California, San Diego, USA. Around the time that I finished my PhD, NCRA was embarking on the ambitious GMRT project. That was a strong motivating factor behind my return to India, so that I could join that effort.

At NCRA, I found myself in the midst of the excitement of building one of the largest low frequency radio telescopes in the world. Here, my combination of training in electronics and astronomy played a major facilitating role, and soon I became the chief scientist and the dean of the GMRT Observatory. This led to my current role as the director of NCRA.

Yashwant at an NCRA conference around 2004. He went on to become NCRA director in 2018.

In the course of this, as the SKA project was conceived, there was significant interest within India about being part of the project, and due to my experience in the building and running of GMRT, it was natural that I take a strong interest in the SKA project. During the SKA design phase, I got the opportunity to lead the consortium that worked on the design of the Telescope Manager system and also to be the science representative from India on the Board of the SKA Organisation. This got me fully engaged in the project as the Principal Investigator for the proposal for India's participation in the construction phase of the SKA telescopes.

What excites you most about the SKA telescopes?

The SKAO is truly a next generation facility that promises to revolutionise many aspects of astrophysics. Pulsars happen to be one of my main areas of research, and the power of the SKA telescopes for pulsar studies is one the most exciting things. Finally, the technologist in me is drawn strongly to the technical challenges on offer.

In terms of your pulsar work, what do you hope to discover using the SKA telescopes? How will they change things?

With the SKA telescopes we expect to detect a very significant fraction of the total pulsar population in our Milky Way galaxy. We expect to find some very exotic pulsars, such as neutron star–black hole binary systems. There should be a quantum improvement in our ability to carry out precision timing of pulsars, hopefully allowing us to convincingly detect very low frequency gravitational waves – both the background, as well as individual sources – fully opening up an exciting new window to the Universe.

What is it about the capabilities of SKA telescopes that will enable this science?

There are perhaps three main capability factors that I think will transform pulsar science: first is the large jump in raw sensitivity that the SKA telescopes will provide that will enable the large number of much fainter pulsars to be detected, and the known ones to be studied with much better quality. The second is the ability to form simultaneously a large number of beams in the sky which will allow the telescopes to cover much more sky area and monitor many more pulsars in much less time than what is possible with the best observatories today. The third is the wide and almost continuous frequency coverage over the part of the radio spectrum where pulsars shine the brightest – this will allow much more comprehensive studies to be carried out, improving the quality of the results.

You mentioned the technical challenges of the telescopes - having led the Telescope Manager engineering design consortium, what is the most complex part of that technology?

The Telescope Manager – now renamed as the Observatory Management and Control (OMC) system – is going to be the brain and nervous system of the entire observatory. In some sense, it will interact with each and every element – both machine and human – of the observatory. These elements are highly varied and distributed over large distances, and the interactions will be complex and span long time durations, all the way from submission of a proposal, to its execution at the observatory, to making the data available to the user, as well as maintaining the facility. This makes the design and implementation of the Telescope Manager / OMC a most challenging activity. It is like a giant jigsaw that all has to fit together to make a coherent picture and it is the job of the Telescope Manager / OMC to make that happen!

> "I see the SKAO as a catalyst that can light up the interest in science and technology in different ways in different parts of the world."

Yashwant at India's GMRT, its landmark radio astronomy facility.

We often talk about the broader impact the SKAO will have beyond the amazing science - do you see that happening already?

I expect the SKAO to act as a bridge bringing together communities from different parts of the world to work together to a common cause. I already saw it happening during the design phase – the Telescope Manager consortium had members from seven different countries working together – and I see it growing much more during the construction phase, as well as during the science operations phase. In addition, I see the SKAO as a catalyst that can light up the interest in science and technology in different ways in different parts of the world. I saw that to some extent in the Vigyan Samagam event in India and see it happening in similar ways in other countries. As the first results start coming from the SKAO, I expect to see that aspect brighten up much more.

You mentioned Vigyan Samagam, the mega-science exhibition which toured India for a year. You were heavily involved in it; what kind of reaction did you get from visitors?

The Vigyan Samagam was a huge success. It drew very large crowds of enthusiastic citizens (especially school and college children) in all four cities that it toured. In addition to just the joy and excitement of learning about so many cutting edge new science ideas and projects, one reaction from the visitors that really touched my heart was the sense of pride that they expressed about India getting involved in so many large projects and that many of these interesting activities were happening on Indian soil – which meant that they could be part of this excitement in the future!

What advice would you give to budding astrophysicists – what kind of skills do they need in order to succeed in this field?

Youngsters aspiring to be professional astrophysicists need to have a broad-based approach to the subject. It is not enough to have good skills only in physics – having a background in instrumentation, software, big data and related techniques and technologies is invaluable, especially if one wants to become a good experimental astrophysicist.

A wider approach to multi-wavelength (and multi-messenger) astrophysics is also needed, as is the ability to work in large international teams. Of course, it goes without saying that the ability to work hard in a focused manner are skills that are still needed, even today!

What has been the proudest moment of your career so far?

The proudest moment of my career was probably being awarded the Shanti Swarup Bhatnagar Award in 2007, which is perhaps the most prestigious science award in India. This was in recognition of my leadership role in getting GMRT fully functional around 2002 to 2003 – overcoming some stiff technical challenges – and shortly after that making some interesting first pulsar discoveries with GMRT, in addition to other areas of research that I contributed to in those years. Perhaps equally close to my heart is the Distinguished Alumnus Award that I received last year (2023) from IIT Kanpur – to be recognised and honoured by one's alma mater holds great value. Another proud moment for me was 21 March 2019 when we officially inaugurated the upgraded GMRT, a project that I had led from start to finish.

Your work must be quite intense, with lots of travelling. Do you have any hobbies that help you to relax?

Nowadays, I don't get too much time to indulge in hobbies. In any case, since I am passionate about my work and enjoy the long hours spent in different aspects of it, the need for taking "breaks" from work to relax is not a compelling requirement for me; and the travel also brings some interesting opportunities for new and different experiences! Music, long walks, time with friends and family are some of the other things that help me unwind.

A rare moment of downtime on the Mohican River in the United States.

African training project DARA gets major funding boost

BY MATTHEW TAYLOR (SKAO)

A project related to the SKAO that trains young Africans in radio astronomy has been given a multi-million euro funding boost.

Development in Africa with Radio Astronomy (DARA) will receive £6.5m (€7.6m) over the next three years, allowing it to train 225 more students on the continent.

DARA began in 2015 when Prof. Melvin Hoare of the University of Leeds used Royal Society and Newton Fund money to [assemble a team to train a first generation of astronomers] in the eight SKAO African partner countries: Botswana, Ghana, Kenya, Madagascar, Mauritius, Mozambique, Namibia and Zambia.

The scheme has been a valuable springboard for talented youngsters, seeding the beginnings of radio astronomy in countries where there was previously little expertise.

While the joint UK-South Africa project has already changed the lives of hundreds of participants, Dr Hoare said there was now a renewed focus on sustainability and helping DARA cohorts utilise skills in radio astronomy and big data that can be applied to other sectors to help address local development challenges, such as farming, deforestation, and water security.

"We've been going for 10 years, but we're only halfway through the real vision," said Dr Hoare.

"We need to get those groups embedded and well-established with more people on board, so that they can become self-sustaining.

"Several DARA PhD graduates now hold faculty jobs in African universities. This is where we want them to be, so they can take up the reins of training people in astronomy themselves and develop programmes for undergraduates and post grads.

"There's still a lot of interest in installing radio astronomy dishes in each of those countries to carry out what is called Very Long Baseline Interferometry (VLBI) – linking up telescopes very long distances apart – not just with the SKA telescopes in the future but, in the meantime, joining the European VLBI Network (EVN) as well.

"It's about having the potential to install, operate, maintain and exploit the data that's coming off those telescopes, and obviously getting ready for when the SKA telescopes come along."

DARA provides training at various levels, utilising various partner facilities:

- Basic training sees UK and South African academics train 10 physics graduates per year from each partner country
- Hands-on training sees students flown to SARAO's Hartebeesthoek Radio Astronomy Observatory (HartRAO), and more recently Ghana's 32 m radio telescope
- Industrial partners from the space sector are involved, including Goonhilly Earth Station Ltd, a radiocommunications site in Cornwall, UK
- Funding for post-doctoral research
- Other DARA support has included funds for computer labs and training equipment

The new funding will come from the UK's Science and Technology Facilities Council (STFC) International Science Partnership Fund, and will be used to further embed skills and develop self-sustaining radio astronomy ecosystems with wider benefits for engineering, physics, big-data handling and other associated fields.

Dr Hoare said: "Looking at big multi-wavelength imaging data sets is the kind of thing you do all the time in astronomy, but it's exactly the same techniques used in Earth observation for example.

"And many of the development challenges that these African countries face can be addressed through Earth observation data – whether it's climate change, food systems, water or energy."

DARA students inspired by their radio astronomy training with a commercial spin-off idea can access tailored advice on how to develop a business plan.

New industrial partners will include Celestia Technologies Group, a large European communications company operating in aerospace, defence, satellite and scientific sectors.

Elsewhere is Trillium Tech, a global research and development company focussing on space AI applications including planetary stewardship, exploration and human health, and which is keen to bring scientists and industry together to tackle particular challenges pertinent to Africa.

Dr Hoare added: "It's looking to the idea of trying to encourage job creation and moving towards the idea of creating space sector hubs.

"A country might have a radio astronomy dish, but how about placing satellite downlink dishes on the same site, and data centre facilities that require fast fibre, a secure compound and associated security – these are the things you need for an observatory.

"It's the idea of co-locating these kind of facilities as a hub where entrepreneurs can come in and gain the necessary skills. They might come in because they're attracted by astronomy, but they might end up spinning out companies that provide data services or other important infrastructure to their countries."

Top and left: Students from Kenya and South Africa during DARA training at SARAO Hartebeesthoek Radio Astronomy Observatory. Credit: NRF/SARAO

Above: Dr Hoare, right, with students during their first experience of looking through a 20 cm optical telescope, as part of the joint DARA training at the Turkana Basin Institute in northern Kenya - a palaeontological research institute famous for the discovery of early hominid ancestors. Credit: DARA/KOTI

The South African Radio Astronomy Observatory (SARAO) will provide dishes to be used as facilities to enhance the local training provided by DARA.

Dr Hoare highlights the mutual benefits to those engaging with burgeoning astronomy expertise in the partner countries.

He said: “DARA all sounds very altruistic of course, but we're keen on building scientific collaborations – especially triangular collaborations between the UK, African partner countries and South Africa.

“We're developing bespoke schemes to try and make sure we attract people back to their home countries, embed them and foster relationships with UK and South African astronomers.”

Another new strand to DARA is a link-up with the University of Edinburgh to provide optical astronomy training on a new 40 cm telescope at the Turkana Basin Institute in northern Kenya – a paleontology institute where many early human ancestor fossils have been found.

DARA funding will also be used to help with site testing on a one metre telescope in Kenya.

Elsewhere, training will be extended to South African students from disadvantaged backgrounds.

“They're really over the moon to just be able to have this opportunity,” said Dr Hoare.

“The thing I'm most proud of over the past ten years is the human stories. It's the life-changing opportunities that DARA has brought. Students who through hard work channelled dreams into reality.”

DARA Big Data

In 2018 DARA Big Data was spun out from the original programme as a sister project.

DARA Big Data brought African students from the SKA partner countries to the UK to study data science at postgraduate level.

It also delivered a comprehensive training programme via workshops and hackathons held on the African continent, using radio astronomy machine learning concepts to put together hack projects in astronomy, agriculture and health sciences.

A typical DARA Big Data hackathon featured up to 40 people working in teams of at least four over two to three days to solve problems buried in real-life data.

One such event asked participants to develop machine learning algorithms to find all of the pulsars in a given dataset; another used Sentinel 2 satellite data to allow participants to predict potential flooding hotspots.

Big Data Africa schools were also held on an annual basis to deliver intensive data science training to those with a good grounding in the concepts, ensuring the development of a pipeline of talent on the continent.

Under the new funding, DARA and DARA Big Data will be combined as “DARA3”.

Prof. Anna Scaife of the University of Manchester led DARA Big Data and will also be involved in DARA3.

She described the funding news as “brilliant”, adding that the introduction of postdoctoral fellowships would help embed skills in-country.

“Over the last few years we've been building this community of postgraduate researchers across the SKA Africa countries. These days, there's a huge network of DARA alumni across Africa. Now it's about supporting those countries to generate a critical mass of embedded research,” said Prof. Scaife.

Generating expertise in big data handling was also critical for a number of projects in Africa, and the likes of the SKA project are important for generating the human capital development required.

“I think the SKA has really spearheaded it across Africa,” said Prof. Scaife. “The SKA is a vehicle for that kind of economic development in the fourth industrial revolution across Africa. That was how it was pitched, and it's been incredibly successful in developing a technological workforce, but the economic impacts of data-driven technologies are much, much broader.”

Prof. Scaife said DARA 3 will concentrate on the links between astronomy and sustainable, data-driven agriculture – important both for Africa and the rest of the world.

DARA in numbers

326 people trained in eight partner countries: Botswana, Ghana, Kenya, Madagascar, Mauritius, Mozambique, Namibia and Zambia.

Produced 26 master's by research graduates and nine PhDs.

DARA Big Data delivered hackathons and workshops to over 600 participants, and produced a further 17 master's and four PhDs.

New funding is now in place to cover the next three years of DARA.

DARA's impact

Dr Emmanuel Bempong-Manful is a Ghanaian national and was among the first DARA graduates.

He is now a research support scientist for e-MERLIN/VLBI facility, an array of seven radio telescopes run from Jodrell Bank Observatory, neighbouring the SKAO HQ.

After gaining a bachelor's degree in physics at the University of Cape Coast and master's in applied nuclear physics at the University of Ghana, he initially struggled to break into the field of astronomy.

He said: “All along I wanted to go into astronomy and astrophysics, but at the time there weren't any well-established astronomy departments in my country and my little or no background in the field had a severe impact on my PhD applications for overseas scholarship/funding in astronomy.

“I wrote to faculties all over the world, including Leeds University, saying I was interested in their research.

“I don't know whether to call it a miracle, or maybe the heavens had an eye on my passions for a long time; just as I was finishing my master's, the DARA programme was starting, and they put me in touch with Prof. Melvin Hoare who advised that I enroll in the training programme in order to gain the relevant background in radio astronomy for future postgraduate opportunities in the field.

“My career is 100% down to DARA. If not for it, I don't know how I would have been able to get into astronomy. It was my launch pad.”

Dr Bempong-Manful said he hoped that continued DARA funding would support creation of the African VLBI Network (AVN) – a series of VLBI-capable radio telescopes being implemented through SARAO, aimed at developing the skills and institutional capacity needed in SKA partner countries to optimise African participation in the SKA telescopes.

“The new funding is very welcome news. To have new funding to develop talent, train people and build capacity is really important to make sure the skills needed are in Africa for the future – not just for the AVN but also for the SKA science and operations.”

“My career is 100% down to DARA. If not for it, I don't know how I would have been able to get into astronomy. It was my launch pad.”

Dr Hoare, third left, with students and the 40 cm telescope at the Turkana Basin Institute in northern Kenya. Credit: DARA/KOTI

Prof. Kristine Spekkens (left) and Prof. Naomi McClure-Griffiths (right)

Senior scientists explore diversity in astronomy

BY MATTHEW TAYLOR (SKAO)

A special programme of the SKAO's regular Speaker Series talks to celebrate International Day of Women and Girls in Science featured the chair and deputy chair of the Observatory's Science and Engineering Advisory Committee (SEAC).

SEAC Chair Prof. Naomi McClure-Griffiths and Deputy Chair Prof. Kristine Spekkens presented a joint talk titled: *Towards Equity, Diversity and Inclusion (EDI) in Astronomy: Australian and Canadian Perspectives.*

The talk provided perspectives on women and other under-represented groups in astronomy through the lens of the Australian and Canadian astronomical communities, assessing the national EDI context, initiatives that are underway, and aspirations for the future.

After an overview of their careers, Prof. McClure-Griffiths and Prof. Spekkens explored thought-provoking statistics on the attrition of women involved in postgraduate astronomy research, as well as assessing affirmative action and retention targets necessary to address the disparity between numbers of men and women in the field, and create lasting change.

Elsewhere, figures on the gender split of telescope research allocation time, and anonymous peer review were discussed.

The SKAO Speaker Series is a regular programme of talks accessible to all within the broader SKA community, covering a wide range of topics, from astronomy to physics, engineering, big data and computing, EDI, and more.

The four talks marking International Day of Women and Girls in Science were:

Kristine Spekkens and Naomi McClure-Griffiths: Towards EDI in Astronomy: Australian and Canadian Perspectives

Gihan Kamel: SESAME and physics collaboration in the Middle East

Leah Morabito: Radio astronomy as a pathway for building global collaborations

Cherry Ng: My personal journey as a female astronomer of colour

All past talks and details of forthcoming talks can be found here.

Left to right: Dr Leah Morabito, Dr Gihan Kamel and Dr Cherry Ng

SKAO membership update

BY MATHIEU ISIDRO AND WILLIAM GARNIER (SKAO)

The start of the year has seen a number of countries progressing towards membership to the SKA Observatory. We look at where things stand as of April 2024.

After announcing its intention to join the SKAO last year, the Canadian government is in the process of finalising its accession as a full member. Canada will soon become the Observatory's 10th member, marking another key milestone in its engagement in the SKA project, which goes back to the beginning of formal SKA activities in 1993 when the International Union of Radio Science (URSI) Large Telescope Working Group was established.

The Christmas 2023 period also brought good news on the membership front, with both the German cabinet and the Indian government confirming their intention to join the SKAO a few days apart.

In Germany, the bill associated with membership of the SKAO has now passed both parliamentary chambers for the first reading unanimously, with all parties supporting the bill. The parliamentary procedure is expected to be finalised during May, marking the final step in Germany's accession to the SKAO.

In India, following the government announcement, the SKAO Convention was signed on 28 March, kicking off the formal ratification process in the country. India has long contributed to the engineering and science behind the SKA project, and as it took part in the treaty negotiations that led to the creation of the SKA Observatory in 2019, India will therefore become one its founding members.

Good progress continues in South Korea, with the hope of engagement at some level in 2024. In Japan however, the SKAO was not selected to appear on the new Japanese research infrastructure roadmap despite widespread support facilitated by the SKA-Japan consortium. Engagement with the Japanese community through the consortium continues in order to identify future opportunities for collaboration until the revision of the roadmap in a few years' time.

Group photograph of meeting between representatives of SKAO, South Korea's Ministry of Science and ICT, the Korea Astronomy and Space Science Institute (KASI) and the UK Embassy in Seoul. Credit: SKAO

SKAO gearing up for first African IAU general assembly

BY MATHIEU ISIDRO (SKAO)

The SKAO is preparing to play a significant part in the first International Astronomical Union (IAU) General Assembly to take place on the African continent later this year, with a series of events and activities planned.

The Observatory is organising a special all-day session on Friday 9 August as part of the conference's programme to update the international astronomy community on the status of delivery of the telescopes and related facilities, upcoming opportunities for future users of the telescopes, as well as discussing science and socio-economic impact, including local and Indigenous engagement, and capacity development around the telescope sites and more widely.

The SKAO is also planning visits to the SKA-Mid site during the conference in collaboration with our local partner the South African Radio Astronomy Observatory (SARAO). This will offer participants the opportunity to see the first few SKA dishes on site as construction of the SKA-Mid telescope progresses, as well as other facilities operating on site like the South African SKA precursor telescope MeerKAT.

The Observatory will also be introducing a new Shared Sky exhibition at the event, featuring new artworks from Indigenous Australian and South African artists that celebrate both countries' long-standing cultural heritage and knowledge of the southern skies.

In recognition of the event's significance and in order to reaffirm our support, the SKAO has committed a significant sponsorship to the General Assembly to help deliver its vision, and is working with South African stand builders HOTT3D to create a visually striking and interactive space that will showcase the Observatory's work and multinational nature.

SKAO joins AfAS in Morocco

BY LETEBELE JONES AND MATHIEU ISIDRO (SKAO)

For the second year running, the SKAO has taken part in the annual meeting of the African Astronomical Society (AfAS), held in April in Marrakesh, Morocco – its first time being held outside South Africa.

AfAS is the pan-African society for professional astronomers. Currently funded by a grant from the South African Department of Science and Innovation, AfAS is expanding its activities to become a focal point for astronomers across Africa, and already counts about 400 members in 22 countries.

To support AfAS' growing activities, the SKAO has agreed to provide the society with a standing sponsorship of €5,000 to help organise its annual conference, in line with the Observatory's existing support for the European Astronomical Society.

Professional and amateur astronomers joined outreach professionals to hear about developments in astronomy on the African continent. The event also provided a valuable networking opportunity for African scientists.

In a plenary session, a number of SKAO officials shared information that gave a broad overview of the organisation, provided an updated status of construction of both SKA telescopes, and looked at the SKAO's science goals, science operations and access for future users.

With the SKA-Mid radio telescope being built in South Africa, many African countries have a direct interest in the project and the SKAO is particularly interested in engaging with them as the Observatory grows. International relations and relationship building with African countries is high on the SKAO agenda along with building capacity on the continent.

The AfAS conference comes before the International Astronomical Union's General Assemby, due to be held on the African continent for the first time later this year, in Cape Town.

Team SKA at the AfAS meeting. Credit: SKAO

Scholarships support early career astronomers

BY CAROLYN MARIE CRICHTON (SKA SWISS CONSORTIUM)

Early career researchers were front and centre at the Cosmology in the Alps Conference, thanks to scholarships funded by its sponsors: the SKA Swiss Consortium (SKACH), the SKAO, and the Swiss National Science Foundation.

Held in Les Diablerets, Switzerland from 18 – 22 March, the international conference welcomed participants from 16 countries. One of its key goals was to foster interactions between experts and researchers who are newer to the field.

Together the three organisations provided scholarships for 24 early career researchers, representing almost a third of the 77 participants. This included six scholarships to attendees from South Africa and Australia, the SKA telescope host countries.

Alongside stimulating talks on radio cosmology studying the Universe on large scales, the participants also heard from Swiss astronaut Claude Nicollier who gave an inspiring welcome address.

Due to the event's success, the next conference has already been set for 16 – 20 March 2026.

Credit: SKACH

A journey across the Universe on board INAF's Time Machines

BY ELEONORA FERRONI (INAF)

More than three tons of wood, 630 linear metres of electrical cables, 586 hours of technical design and project management, 320 hours of graphics and visual design, 200 hours of setup, and 950m² occupied by the exhibits.

These numbers describe the Time Machines exhibition, a cosmic journey across the Universe conceived and designed by Italy's National Institute for Astrophysics (INAF).

This perfect combination of scientific dissemination, fun and culture was held from 25 November 2023 to 24 March 2024 at the esteemed Palazzo Esposizioni in Rome. The SKAO featured prominently on the walls of the exhibition, alongside SKA precursor telescopes ASKAP in Australia and MeerKAT in South Africa, with Italian and English text helping to explain the Observatory's goals for locals and international visitors alike.

In its first month, over 1,500 children and students aged between three and 18 years old attended the exhibition, and by the end of its four-month showing more than 31,400 visitors had been welcomed through its doors.

The public programme ranged from educational workshops and lectures to entertaining science shows. INAF organised a conference of high-level scientific talks with prominent names in the field, including astronaut Roberto Vittori who gave the inaugural lecture. Another highlight was a seminar by Michel Mayor, winner of the Nobel Prize in Physics 2019 for the discovery of the first exoplanet.

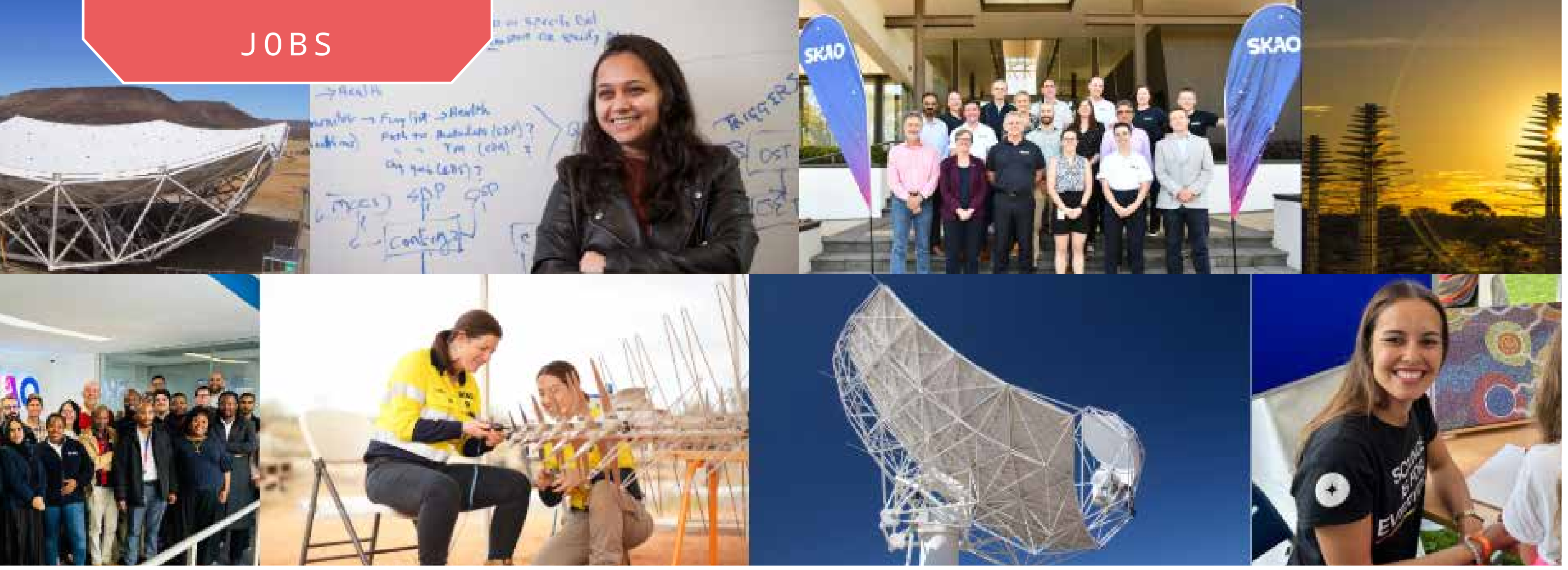
Time Machines featured many inclusive elements: sonification software that allows visitors to "feel" the images, tactile representations that provide information on the different areas of an image, and videos in Italian Sign Language.

"Engaging, accessible and inclusive exhibitions like Time Machines are powerful tools to reach audiences of all ages and backgrounds, bridging the gap between astronomy and the general public and fostering a deeper appreciation for the importance of scientific research," says Caterina Boccato, astronomer and public engagement manager at INAF, and curator of the exhibition.

Having embraced a modular approach in its conception, Time Machines can be scaled accordingly and be adapted to different venues. As such, it will soon tour Italy and – hopefully – Europe.

"Transforming our project into a travelling exhibition is part of our commitment to reach diverse communities nationwide. As astronomers, we are explorers of the cosmos and storytellers of its mysteries: we hope to inspire the next generation of scientists to reach for the stars and explore the unknown."

Credits: INAF / Paolo Soletta & Azienda Speciale PalaExpo / Claudia Gori



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.

Director of Programmes

The SKA Director of Programmes will have the drive, vision and leadership to ensure that the SKA Construction Project is delivered to time, budget and specification, leading a large directorate of skilled project, engineering and technology staff located across the UK, South Africa and Australia.

APPLY HERE

Conferences and Events Lead

The Conferences and Events Lead will play a central role in the organisation and/or participation of the SKA Observatory in large-scale international meetings, professional conferences, as well as recreational and outreach events.

APPLY HERE

SKA-Low jobs via CSIRO

- Platform Engineer
- Data Processing Manager
- Engineering Operations | Multiple Positions
- Engineers and Developers | Computing and Software | Multiple Positions
- Telescope Operator/ Data Analyst

APPLY HERE

SKA-Mid jobs via SARAO

- IT Officers
- Signal Processing Engineers
- Pipeline Engineers
- Senior Platform Engineer
- Control Software Engineers
- Senior Execution Framework Engineer
- Network Technicians
- Site Reliability Engineering Manager

APPLY HERE

SKAO in the news

ABC News
First antenna is installed on Square Kilometre Array Low telescope, as traditional owners welcome project
Australia's public broadcaster reports from the first SKA-Low antenna deployment and speaks to members of the Wajarri Yamaji community.

Electronics Media
GMV has been awarded the contract to develop the SKA telescopes' Timescales
A look at the contract for the SKA telescopes' central clock system which will ensure signals are precisely aligned across the arrays.

Engineering News
A prototype dish for the SKA has started early science work in the Karoo
A report on the first light of the SKAMPI dish, a prototype for SKA-Mid (see page 22).

Financial Express
What's Square Kilometre Array Observatory? As India joins mega project, know all about world's largest radio telescope
India's Financial Express explores India's history within the SKA project, following the announcement that it will become a full member of the Observatory.

My Broadband
The big lift - First dish of world's biggest radio telescope in South Africa going up soon
The South African technology news website looks ahead to the assembly of the first SKA-Mid dish on site.

Science and Technology Daily
Joint efforts to build world's largest radio telescope
The official newspaper of China's Ministry of Science and Technology reports on the international collaboration behind the SKAO, and speaks to Director-General Prof. Philip Diamond during the SKAO Council meeting in Nanjing in March.

Video spotlight: The first SKA-Mid dish arrives in South Africa
Earlier this year, members of the SKA-Mid telescope team were on hand to welcome the first dish when it arrived in Cape Town, after a 16,000 km journey from the manufacturing site in China.

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.

SKAO Director-General Prof. Philip Diamond was awarded a prestigious CBE in the UK New Year's Honours in recognition of his services to global radio astronomy. Prof. Diamond received his medal from the Princess Royal at Windsor Castle on 23 April.

SKAO Council Chair Dr Catherine Cesarsky was awarded the European Astronomical Society's Fritz Zwicky Prize for Astrophysics & Cosmology, recognising her outstanding contributions to the understanding of galaxy evolution, and her leadership in shaping contemporary astronomy infrastructure.

Dr Phil Mjwara, who recently retired as director-general of the South African Department of Science and Innovation (DSI), received the South African Medical Research Council's President's Award for his "visionary leadership in promoting science in South Africa". Dr Mjwara served in the post for 18 years, and was also South Africa's representative on the SKAO Council until his retirement in March.

Dr Ann Njeri, a member of our VLBI Science Working Group and DARA Project alumna, has been awarded a L'Oréal-UNESCO for Women in Science UK and Ireland Rising Talent award. The awards support women pursuing scientific research careers.

The International Centre for Radio Astronomy Research (ICRAR), one of the SKAO's partners in Australia, has welcomed a new executive director following a comprehensive global search. Prof. Simon Ellingsen takes up the post from April 2024.

The UK's Royal Astronomical Society annual awards included prizes for astronomers who participate in the SKAO's Science Working Groups:

Prof. Leah Morabito (Durham University), chair of the UK SKA Science Committee, received the Fowler Award for pioneering work on ultra-high definition imaging with SKA pathfinder LOFAR.

Prof. Ryan Shannon (Swinburne University) received the Jackson-Gwilt Medal with Dr Keith Bannister (CSIRO) for work on fast radio bursts with SKA precursor telescope ASKAP.

Prof. Pedro Ferreira (Oxford University) received the Eddington Medal for work on cosmological observations.

CONTACT – THE SKAO'S MAGAZINE

Published by the SKAO Communications team.

Editor: William Garnier
william.garnier@skao.int

Managing Editor: Cassandra Cavallaro
cassandra.cavallaro@skao.int

Editorial team: Mathieu Isidro, Liz Williams, Letebele Jones

Staff writers: Matthew Taylor, Sebastian Neuweiler

Science liaison: Dr Tyler Bourke

Design: Joe Diamond, based on an original design
by Carbon Creative

Cover design: Martin Hadfield, Craig Davis, Carbon Creative

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

All images in *Contact* are courtesy of 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

A celebration of the construction progress seen across both SKA telescope sites in early 2024, from the deployment of the first SKA-Low antennas in Australia, to the assembly of the first SKA-Mid dish in South Africa.

Contact is produced primarily as a digital magazine. If you are reading a print copy, use the QR code to read this and other issues of *Contact* online, access the hyperlinks, and subscribe to *Contact's* mailing list.