CONTACT

THE SKAO'S MAGAZINE

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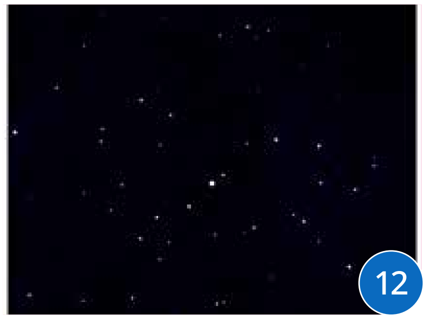
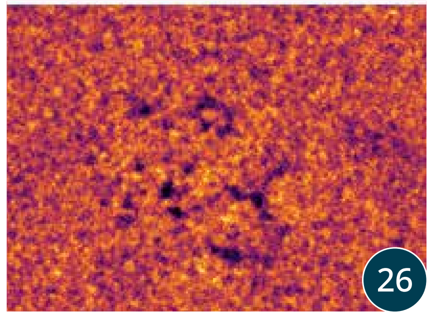




Another "big lift" of an SKA-Mid dish – read more on page 8.

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

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

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

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

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

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

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

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

PROF. PHILIP DIAMOND, CBE
SKAO DIRECTOR-GENERAL

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Lives and deaths of stars

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

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

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

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

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

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

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

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

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

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

Prof. Naomi McClure-Griffiths

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

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

Interstellar investigations

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

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

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

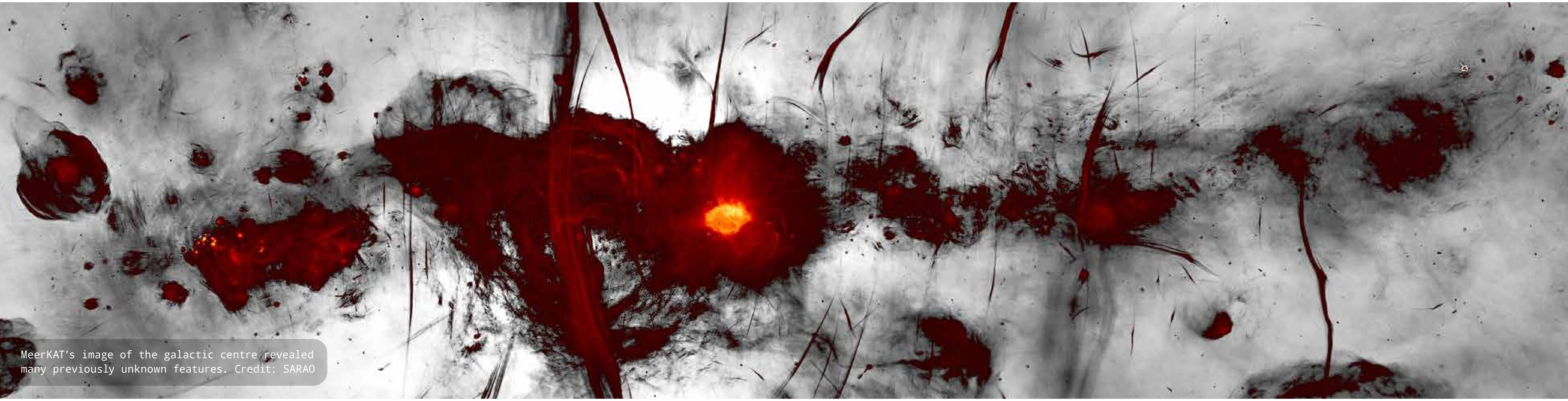
An important tracer for these studies is the 21 cm emission line from neutral hydrogen gas, which is abundant in the interstellar medium.

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

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

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

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



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

Dr Filippo Zerbi becomes new SKAO Council chair

BY CASSANDRA CAVALLARO (SKAO)

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

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

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

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

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

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

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

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

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

Sweden on home straight to SKAO membership

BY CASSANDRA CAVALLARO AND JOSH RODDEN (SKAO)

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

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

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

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

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

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

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

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

CONTACT – THE SKAO'S MAGAZINE

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We welcome your contributions to *Contact*!
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ABOUT THE SKAO

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

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

FRONT COVER

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

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