Astronomy

http://www.ska.ac.za/

The news that South Africa will host the majority of the Square Kilometre Array radio telescope (SKA), which will be 50 times more powerful than any other radio telescope in existence, has placed the country firmly on the map of international astronomy research. In partnership with Australia, South Africa will be making a significant contribution to the understanding of the origins and evolution of the Universe, the notion of dark matter and dark energy, and the probability of life elsewhere. The possibilities are firing up a new generation of scientists at UCT.

It's written in the stars: South Africa is set to make its mark on astronomy

The much-anticipated announcement that South Africa will host the majority of the Square Kilometre Array radio telescope (SKA) – made in 2012 but reflecting the work of the South African astronomy community over many years and culminating in the submission of the final bid in 2011 – is no small achievement. Researchers in UCT's Department of Astronomy have supported the SKA bid in many ways. When Professor Renée Kraan-Korteweg, head of the department, joined UCT in 2005 after a successful tenure at the University of Guanajuato in Mexico, she knew capacity development and radio astronomy development would be imperative to put South African astronomy on the map. It was important to show the world that South Africa would not only provide space for the SKA, but also expertise.

"It was clear that the South African government had an idea to start flagship projects to show how we can manage projects that are up there with the rest of the world," she says. "There was also a realisation that the younger generation of South Africans and Africans need to be motivated to pursue careers in science and technology."

As a result, South African astronomy – with the UCT Department of Astronomy at the forefront – has grown at an almost unprecedented rate, with renewed interest sparking among a new generation of scientists. Today, there are dozens of students joining the field and moving on to postgraduate and postdoctoral level.

"In 2005, there were only two professors and one postdoctoral researcher in the department, with three to five postgraduate students. At present we have 10 staff members (including four professors), 11 postdoctoral fellows and more than 30 postgraduate students," says Professor Kraan-Korteweg.

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On a teaching level, the development of an undergraduate major in astronomy has contributed to this growth, with up to 45 students registering for astronomy majors per year, in comparison with the initial eight to 10 students in 2006.

"This growth has taken place largely because of the opportunities on the horizon, and UCT has the only dedicated astronomy department in the country," she says.

A catalyst for transformation

Astronomy has become a catalyst for transformation as well, says Professor Kraan-Korteweg. Transformation has certainly characterised the subject's growth among her students – 75 percent of UCT's undergraduate programme are black South Africans. Although UCT has the only astronomy department in South Africa, there are other initiatives contributing to the growth of this sector. For instance, the National Astrophysics and Space Science Programme (NASSP), hosted by UCT, is a nationwide programme that was launched in 2003 and focuses on the development of honours and master's degree students in the astronomy and space science sectors by providing adequate bursaries that will also make this career option attractive to previously disadvantaged South Africans.

The DST/NRF South African Research Chairs Initiative (SARChI) has also been integral in the growth of the department, with the appointment of professors Erwin de Blok (2007) and Claude Carignan (2011) as holders of SARChI Chairs in Astronomy.

While Professor de Blok's role as a SARChI chair holder was specifically aimed at increasing the radio astronomy expertise in the department, Professor Carignan's role is to grow local astronomy to create the next generation of astronomers, who might be actively involved at the SKA when it is to be completed in 2025.

Deputy Vice-Chancellor Professor Danie Visser and SKA SARChI Chair holder Professor Claude Carignan, at the MeerKAT site in the Karoo, pictured here with the KAT7 telescopes.

Professor de Blok has since taken up a senior position at The Netherlands Institute for Radio Astronomy (Astron), but will continue his work through student supervision and his involvement in Mhongoose, one of UCT's four internationally-approved projects allocated for MeerKAT. To fill Professor de Blok's shoes as SARChI chair holder, Dr Tom Jarrett from the California Institute of Technology (CALTECH) was appointed to continue the department's growth in the field of multi-wavelength astronomy.

When ready in 2016, MeerKAT will be one of the most powerful radio telescopes in the world. It will then be supplemented with 180 further dishes to form the SKA Phase 1 dish array and will be instrumental in internationally groundbreaking work in its own right until the completion of the SKA in 2025.

Following the 2010 international call for large survey proposals on MeerKAT, 21 proposals were received, of which 10 were accepted. Four of the 10 projects are led or co-led by researchers from UCT. These are LADUMA (Dr Sarah Blyth), MIGHTEE (Dr Kurt van der Heyden), ThunderKAT (Associate Professor Patrick Woudt and Professor Rob Fender), and the above-mentioned Mhongoose.

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The UCT MeerKAT projects vary from the study of nearby galaxies, understanding how stars are formed and the distribution of material and dark matter in the galaxies (Mhongoose), to discovering more about active galactic nuclei, bursts and explosive events in galaxies in the quest to develop a greater understanding of galaxy evolution (MIGHTEE), to the evolution of neutral gas in the Universe (LADUMA), and the search for Dynamic and Explosive Radio Transients (using radio telescopes to study energy outflows caused by events such as novae

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and supernovae or the relativistic outflow of material from an accretion neutron star or black hole) with MeerKAT (ThunderKAT).

The department's access to SALT (the Southern African Large Telescope in Sutherland) allows them to combine optical and radiotelescopic images. This is significant because a complementary telescope working at a different wavelength provides a different – and therefore very valuable – piece of the puzzle to researchers. This is particularly relevant for LADUMA, which has been rated as one of two Priority Group 1 surveys to be performed on MeerKAT.

Through SALT, researchers measure the distances to the galaxies (redshifts), enabling them to calculate the average (neutral gas) mass of galaxies in their observations. The survey will be the deepest neutral hydrogen survey to date and has been awarded 5 000 hours to observe a single pointing centred on the Extended Chandra Deep Field South (ECDF-S), with the aim of observing neutral hydrogen in galaxies out to redshifts greater than one.

Associate Professor Patrick Woudt explains the real-time observations that will be done with MeerKAT within the ThunderKAT project will open a new time domain in astrophysics. "The multi-wavelength approach is critical in modern-day astrophysics," he says.

"By looking at the sky in very high cadence, you can see the variation of celestial bodies quickly and when you see it in real time, you can trigger an immediate follow-up at other telescopes to study the object during an outburst. That was not possible in the past – the real-time element is enabling new science."

Associate Professor Woudt emphasises there is more than enough reason to be excited about the projects involving MeerKAT and its precursor KAT-7, regardless of the SKA.

"Each of the (MeerKAT) projects involves teams of between 30 to 50 people from the international astronomy community, who are experts in the field and everyone is excited to come to South Africa to work on MeerKAT. It is obvious that the South African landscape is changing for astronomy."

As was seen over the past year with KAT-7, astronomy breakthroughs aren't waiting for MeerKAT or the SKA, with the capture of images of the first atomic hydrogen spectral line of NGC 3 109, a small spiral galaxy about 4.3 million light-years away from earth, located in the Hydra constellation. The department announced in March 2011 that the team, led by UCT PhD student Bradley Frank, saw neutral hydrogen gas (HI) emission, as well as the movement of the galaxy itself, linking up to the science planned for MeerKAT and the SKA, where astronomers are planning to map the Universe and determine how it has changed over time.

As the South African SKA Research Chair in Multi-Wavelength Astronomy in the department, Professor Claude Carignan believes this is only the beginning of many breakthroughs to come.

"One of the big science drivers for the SKA is to look for neutral hydrogen. We have shown we can do it with seven antennas (from KAT-7). When MeerKAT is up and running, with its 64 antennas, we will do research that cannot be done anywhere else."

Research grouping associated with this theme

■ Astrophysics, Cosmology and Gravity Centre

The Astrophysics, Cosmology and Gravity Centre (ACGC) is a research centre incorporating members of the UCT Department of Astronomy and the Cosmology and Gravity Group from the UCT Department of Mathematics and Applied Mathematics. The ACGC aims to create a research environment at UCT in which South African-led cutting-edge science projects will be discussed, developed and taken to fruition. Maximising the opportunities for interaction between theorists and multi-wavelength observers is essential for stimulating new approaches to research. The centre also aims to become an attractive location for postgraduate students and postdoctoral fellows, as well as international visitors.
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DST/NRF SARChI Chairs associated with this theme

Multi-wavelength Astronomy at UCT

Professor Claude Carignan completed his PhD (1983) at Mount Stromlo and Siding Spring Observatory of the Australian National University, where he pioneered the multicomponent analysis technique of galaxies' rotation curves using both radio HI and optical Ha kinematical data. He pursued his formation in HI radio synthesis work through a postdoctoral fellowship at the Rijksuniversiteit in Groningen, using data from the Westerbork array. He then moved to the Université de Montréal as a research associate and became a full professor in 1998. In 1998, he took over the directorship of the Observatoire du Mont-Mégantic Research Centre and in 2002 became Director of the Observatoire du Mont-Mégantic (OMM).

In 2007, he became adjunct professor at the Université de Ouagadougou, in Burkina Faso, where he has set up an astrophysics programme and built a small observatory for teaching purposes. At the end of 2009, he moved a telescope from Chile to Burkina Faso, which was to form part of a new research observatory that is currently under construction and should be completed in 2012. Finally, he was awarded the SARChI Research Chair in Multi-wavelength Astronomy at UCT in 2011.

Astrophysics and Space Science

UCT was awarded this Chair in view of astronomy as a strategic priority nationally and within UCT (the only university in the country with an academic astronomy department), and the national bid for the hosting of the Square Kilometre Array (SKA). Professor Erwin de Blok held this position until the end of 2011, with Dr Tom Jarrett (far left) succeeding him in 2012. Dr Jarrett joins UCT from the California Institute of Technology. His research interests and expertise lie in the extragalactic large-scale structure – and visualisation thereof – of the nearby Universe, the Zone of Avoidance, interacting galaxies, star formation processes and galaxy evolution.

Widening the net of collaboration

The Department of Astronomy is not neglecting the importance of collaboration with other university departments and groups in and outside Cape Town. There is inter-departmental co-operation within the Astrophysics, Cosmology, and Gravity Centre (ACGC), close co-operation with the departments of electrical engineering and computer science, the traditional close ties – and joint positions – with the South African Astronomical Observatory and, more recently, with the KAT-office in Pinelands, the recently formed astronomy group at the University of the Western Cape, the African Institute of Mathematical Sciences (AIMS), the University of the Witwatersrand, and the newly-established SKA DST/NRF SARChI Chair at Rhodes University.

Professor Kraan-Korteweg is confident that South African astronomy and science in general will benefit from these collaborations. "We still need human resources

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for instrumentation development, software and hardware development, and data analysis tools. The majority of the work that needs to be developed does not purely involve scientists in astronomy, but also in other groups like engineering and computer science."

"We are becoming the astronomy hub in Africa," says Associate Professor Woudt. "It's a very exciting and vibrant community, so the SKA will, of course, be a huge science engineering project leading to the further development of science and engineering on the continent. It will enable many deeper, better, faster views, and there are plenty of potential Nobel prizes in there. There is groundbreaking science to be done."