

A world leader in Radio Astronomy

The Rhodes University Centre for Radio Astronomy Techniques and Technologies

That South Africa is on the world Radio Astronomy horizon in such a way as to have successfully won two-thirds of the SKA bid, is to a significant extent due to the impact of academics and graduates of the Radio Astronomy research programme at Rhodes University.

Rhodes' renowned Radio Astronomy Unit, established over a half century ago, has made a significant contribution to the development of the KAT-7, the MeerKAT array, and to radio astronomy in South Africa and worldwide.

Building on this legacy, in 2011 Rhodes established the Centre for Radio Astronomy Techniques and Technologies (RATT), a research entity within the Department of Physics and Electronics, the Director of which is Professor Justin Jonas.

Prof Jonas is one of South Africa's foremost radio astronomers and the Chief Scientist on the SKA project. Several Rhodes alumni, including Rhodes graduate Dr Adrian Tiplady (the SKA Site Bid Manager), support him.

The longest legacy in Radio Astronomy Rhodes has the longest legacy in Radio Astronomy of all South African universities, dating back to the 1950s when the groundbreaking work of Professor Jack Gledhill in the area of solar system astronomy first attracted international attention. Subsequently, well known names such as Professor Eddie Baart,

Professor Graeme Poole, Professor Gerhard de Jager and Dr Gerhard Verschuur, extended this work to studies of Jupiter. From 1976 the Hartebeeshoek Observatory (now HartRAO) was developed as a world class Radio Astronomy facility, largely as the result of the involvement of students, graduates and staff from

Rhodes, in the development of instrumentation and techniques. Twenty years later South Africa made a decision, in 1996, to invest in a small number of core areas of fundamental science. As Prof Jonas explains: "We are a smallish country and it made sense for us to only really invest in areas of fundamental science where we had a natural advantage.

Astronomy was chosen as one of these because South Africa is a good place to do astronomy." Southern Africa - a science destination There was always a drive to build up astronomy in southern Africa and the SALT telescope - the Southern African Large Telescope, an optical telescope – is now operating in South Africa.

SALT is the largest optical telescope in the southern hemisphere. Namibia has the HESS telescope, which is the largest gamma-ray telescope in the world, and so the next ground based astronomy waveband that there is, and the only other one, is radio, so it was the logical thing to go after.

Securing SKA is “huge and really fantastic” said Prof Jonas. “I think this will really change the perception of Africa in all sorts of ways, and I think from outside and within, that it will be seen as a science destination, as opposed to a continent of resources or a place where you go for tourism or perhaps a place which just gets hand-outs.

This is now going to be - perhaps for the first time - where Africa will be able to look at the rest of the world as peers in the science community.” A world leader in Radio Astronomy The SARChI SKA Chair forms part of the Centre for RATT and will help develop algorithms and techniques for the SKA.

SARChI SKA Chair holder, Professor Oleg Smirnov, has great ambitions for the Centre and wants to turn it into “a world leader in Radio Astronomy”. Current members of the academic staff of the Rhodes Department of Physics and Electronics will contribute to the research work of the Centre.

Of specific significance is the contribution made by Prof Jonas, whom Rhodes seconded first to the Directorate of HartRAO and then to the South African Square Kilometer Array (SKA) Project Office (SASPO) for the past eight years. This has been a huge personal contribution on the part of Prof Jonas, and huge institutional contribution on the part of Rhodes, to the National effort in Radio Astronomy and South Africa’s competitive position in attracting the SKA.

This heritage, focus and momentum make Rhodes an ideal intellectual environment for hosting the SKA Chair. Three significant contributions that Rhodes researchers have made in the scientific arena that have provided legitimacy to the SKA SA project and valuable links to international institutions and individual researchers are:

- The study of glitches in pulsars by Claire Flanagan (which resulted in a paper in Nature);
- The 2.3 GHz Survey of the Southern Sky which has become a highly cited data set; and
- The development of the algorithms for spectropolarimetric interferometry by Athol Kembell.

Honours, Masters and Doctoral scholarships Prof Smirnov’s first priority will be to recruit “some bright postdocs and students”. “I need to get a group together. There are currently too few people working on these things - certainly fewer than the SKA will need - so there’s quite a vacuum to be filled.

Prospects are good!” Prof Smirnov will be supported by an administrator, two to three full time researchers/postdocs, and a group of Masters and PhD students. Applicants with strong academic records looking to get involved in the field of Radio Astronomy, MeerKAT and the SKA have been invited to apply for Honours, Masters and Doctoral scholarships tenable from 2013.

Rhodes has an established record of research and teaching excellence, and a reputation for research outputs and throughput rate in a number of focused areas. Outputs of the SKA Chair are intended to be of the traditional scholarly kind (papers and technical reports, MSc and PhD graduates), as well as artefacts such as algorithms and techniques that will be deployed by the MeerKAT and SKA projects.

Strategic direction

The Centre for RATT's strategic direction will be closely tied to the strategies for MeerKAT and SKA, through the tight coupling of Prof Jonas' appointment to both Rhodes and the SKA Project Office (SASPO).

The Centre will be accountable internally to departmental and faculty management structures, especially the Head of Physics and Electronics Department as far as the utilisation of space and equipment is concerned, and for joint planning on academic programmes and the registration of research students.

For institutional support and governance, the Director of the Centre will report to the DVC: Research & Development (and the Dean of Science, as appropriate) around research goals, resource needs, governance, performance monitoring, and compliance (institutional goals, financial, ethical standards, and intellectual property management).

Research focus

The research focus will be in the area of Radio Astronomy Instrumentation, specialising in techniques and technologies needed to build the next-generation of radio astronomy telescopes, and to make possible the science that these telescopes will enable, and encompassing electronics, algorithms and computing for Radio Astronomy Data Processing.

It will build upon the University's existing areas of expertise:

Techniques:

- Algorithm Development
- Software Development
- Image Processing Technologies:
- Reconfigurable computing
- Digital signal processing
- High speed electronic support

Close engagement with MeerKAT An essential part of the research plan of the Centre for RATT is a close engagement with the people in the MeerKAT office in Cape Town, ensuring a direct relevance of the work at Rhodes to the SKA/MeerKAT effort, and using them as research associates connected to the University.

They will collaborate on research projects and assist with student supervision, and as contributors to the critical mass of activity around the SKA Chair. As the SKA's precursor, MeerKAT requires research into the same kinds of problems, hence it made sense to unite the two groups, says Prof Smirnov.

"It will also give my Rhodes students an opportunity to spend time with the MeerKAT project, which is a fantastic environment for young people to get immersed in." Prof Smirnov

plans to split his time between Cape Town and Grahamstown. He has also been asked to lead the Radio Astronomy Research Group at the MeerKAT project office in Cape Town, which will work together with the Centre for RATT on the same subjects.

Strong international links and collaborations

The Centre for RATT through the Rhodes' Department of Physics and Electronics is engaged in strong international collaborations and has established links, amongst others, with:

- The University of Illinois Department of Astronomy and the Laboratory for Extreme-Scale Astronomical Processing (LEAP) (Rhodes graduate Dr Athol Kemball);
- Oxford University (Head of Astrophysics);
- ASTRON - the Netherlands Foundation for Research in Astronomy (Prof Mike Garrett, General Director of ASTRON);
- The Max Planck Institute for Radio Astronomy (radio continuum mapping),
- The University of Hertfordshire's Centre of Astrophysics in the UK (Dr Matthew Jarvis, Reader in Astrophysics and RCUK Academic Fellow);
- The NRAO in the USA (National Radio Astronomy Observatory). Prof Jonas is highly proactive about developing the calibre of the above partnerships, which are essential to South Africa's success in the MeerKat and SKA projects.

Other collaborations in the pipeline are:

- The Max Planck Institute for Radio Astronomy in Bonn, for pulsar and time domain and radiotransients (Prof Dr Michael Kramer, Director);
- JPL - the Jet Propulsion Laboratory and Caltech;
- University of California at Berkeley;
- Cornell University;
- Cambridge University.

Strong local links and collaborations

Strong links already exist between Rhodes and the University of Fort Hare and Nelson Mandela Metropolitan University. The Centre for RATT will look to strengthen its partnership with the Eastern Cape regional universities as part of the existing institutional strategy to work together to overcome the geographic isolation of the region.

In addition to the very strong links with the SA SKA/MeerKAT project and HartRAO, Rhodes also has a very strong relationship with the South African National Space Agency (SANSA) Space Science Centre, where Rhodes graduate and Ionospheric Research Physicist, Professor Lee-Ann McKinnell, is both Managing Director of the centre and a visiting Professor of Rhodes University. SANSA national CEO, Dr Sandile Malinga, is also a doctoral graduate and former lecturer of the Rhodes Physics Department.

The unique characteristic of the Radio

Astronomy focus at Rhodes

The unique characteristic of the Radio Astronomy focus at Rhodes is the specific mix of subjects that support graduates in the field. Graduates emerge with Physics, Electronics, a good grounding in the areas of Mathematics that provide the necessary analytic skills, and enough Computing to be highly competent in algorithm design.

This is an excellent mix of skills for forefront research in Radio

Astronomy, enabling graduates to become accomplished in both the science and engineering aspects of radio astronomy. There is

international recognition that this mix of skills and competencies is in short supply, and that individuals with such a background are highly valued by

the Radio Astronomy community. Strong inter-departmental collaboration

Outside of the direct Radio Astronomy focus, there is a strong cluster of departments, groups, and institutes at Rhodes involved in intellectual and practical pursuits which relate in various ways to the scope of this Centre, and which provide a context and collegial environment for the SKA Chair.

They include:

- The Physics and Electronics theoretical physics and electronics programmes;
- Pure and Applied Mathematics, which includes a strong computational mathematics focus, and a world leading research group in gravitational radiation;

- Computer Science with a strong track record in grid and cluster computing, telecommunications, and graphics/image processing.

The following Academic Departments at Rhodes are involved in research and teaching in cognate disciplines related to high performance computing, algorithmic and mathematical techniques, and economic, social, or business models that might apply to initiatives such as the SA SKA/MeerKAT effort:

- Biochemistry, Microbiology & Biotechnology
- Chemistry
- Economics
- Environmental Education
- Environmental Science
- Geography
- Geology
- Rhodes Business School
- School of Journalism and Media Studies
- Statistics
- The Centre for Social Accountability which incorporates the Public Service Accountability Monitor
- The Institute for Social and Economic Research

With the SKA underway, Prof Jonas is inspired by what the Centre for RATT and the SKA Chair might achieve. “We’ll be looking back to the very beginning of the universe and trying to understand what happened when the universe moved out of the so-called Dark Ages into the light when the first stars and galaxies formed. Following on from that, we’ll be trying to understand how the stars and galaxies evolved over time to where we are now.”

Prof Jonas says there are so many questions they have been asking for a long time and with the help of the SKA they will hopefully be able to answer, such as: Why did the universe support magnetic fields?

Where did they come from? Are there signals coming from molecules, which could be precursors of life? And of course the biggie would be if the SKA detects a real extraterrestrial signal. Another important area they’ll be investigating is basic physics, Prof Jonas explains. “Was Einstein correct in his theory of relativity, in his theory of gravitation? By using pulsars we’ll be really probing

Einstein’s theory very, very deeply. “Those are the sorts of science cases which have been put forward to justify, if you like, the SKA, but all of us really hope that it will be known for something that we hadn’t predicted, and that we’ll discover something completely new.”