SKA, Science and South Africa

Over the next couple of decades the Square Kilometre Array (SKA) has the potential to propel science and South Africa into the universal age.

The SKA will consist of thousands of radio antennas which will detect electromagnetic waves emitted by objects in space and it will be 50 times more sensitive than any of the existing radio telescopes. It is expected to pinpoint the nearest 100 million galaxies and may also cast light on 96% of the universe's energy and matter which cannot currently be picked up by telescopes - including the mysterious "dark energy", a negative pressure that is causing the cosmos to expand at an ever increasing rate.

The SKA will furthermore record light that was emitted as far back as two to three hundred million years after the Big Bang, when only two percent of the current universe was formed. This will for the first time offer insight into the formation and evolution of the first stars and galaxies. "It will challenge the current building blocks of fundamental science, including Albert Einstein's century-old Theory of General Relativity which will be tested by the SKA's ability to look at the gravitational forces around black holes," says Professor Justin Jonas, Associate Director for Science and Engineering of South Africa's SKA programme and Professor of Physics and Electronics at Rhodes University.

Radiation emitted by intelligent life in other solar systems may also be picked up by the SKA, which will be able to detect the equivalent of airport radar on a planet fifty light years away. Given the wide range of interests covered by the SKA, it is expected to be one of the dominant platforms of scientific discovery for many decades to come. The academic appetite for this kind of telescope is evident.

Three hundred international scientists have already booked research time on South Africa's MeerKAT telescope project (a precursor to the SKA, designed and built locally) - which will go into service in 2016. "Winning the SKA will be a massive boost for South African society. It will bring great prestige to the country and usher a new generation of science students into higher education," says Rhodes University Vice-Chancellor, Dr Saleem Badat. "SA's SKA bid highlights the fact that African scientists are capable of making cutting edge contributions," says Professor Ric Bernard, Dean of Science at Rhodes University.

"It also reflects what our Science Faculty can and has achieved." Jonas, along with Dr Adrian Tiplady, the site characterisation manager at SKA South Africa, and a number of other Rhodes alumni, have been instrumental in developing the SKA site in SA and designing the MeerKat telescope.

The University's role in the SKA bid has been recognised with the award of the prestigious SARChI Chair in Radio Astronomy Techniques and Technologies by the South African government. Professor Oleg Smirnov, formerly of the Netherlands Institute for Radio Astronomy (ASTRON) has been appointed to the Chair. This will catapult Rhodes's 50 year-old Astronomy Unit, which deserves kudos for its role in designing much of South Africa's SKA telescope technology, into a new era, says Dr Peter Clayton, Rhodes University's Deputy Vice Chancellor Research and Development.

The excitement surrounding the SKA is capturing the imagination of students who want to be part of the project, and creating a new career trajectory for a large number of students who excel in mathematics, physics and computer science, says Prof Bernard.

The Department of Science and Technology has allocated almost 300 bursaries to develop human capital for the SKA project, and Prof Jonas says it is already started paying off. A large number of young new radio astronomers are coming through the ranks.

Prof Bernard adds that Rhodes has also seen outstanding mathematics and physics students from rural Limpopo and the Eastern Cape coming to the University. “The SKA will create a really exciting focus for them and we hope that it will attract many more such students to Rhodes.”

Dr Clayton says Rhodes’s prominent involvement in the SKA can be attributed to the University’s emphasis on research and academic freedom. The institution has one of the highest rates of PhDs among academic staff (55%), while its lower student-to-lecturer ratio offers the highest level of personal academic attention in the country.

Prof Jonas has credited this level of personal academic attention as key to his development as a scientist.

Apart from the SARChI SKA Chair, the university has also recently been awarded a number of other prestigious research chairs. While Rhodes represents less than one percent of South Africa’s student body, it now holds 7% of all national research chairs.

Dr Badat says this kind of academic research culture took years of intellect and effort to establish. “It was developed brick by brick, microscope by microscope.” He expects that the SKA’s requirements for more scientists and technologists will provide a further boost in expanding the University’s capacity and scientific reach.

While the SKA will clearly have enormous impact on science, it also has the potential to change the lives of ordinary South Africans, believes Dr. Badat. As the SKA addresses some of the universe’s bigger questions, it also has to solve a great number of technical problems and the applications could be of huge potential benefit to the whole country.

One of them is the capacity for what Prof Jonascalls “extreme computing”. To compute all the data it will receive from thousands of antennas, the SKA will require the world’s fastest computer, with the processing power of approximately one billion PCs. It will have to cope with 10 times the global internet traffic every day.

South Africans have made some strides with this - MeerKAT has seen the development of the reconfigurable open architecture computing hardware (Roach) board, which enables specialised, superfast computing. Agreements for further research and development with corporate giants like Intel (processors) and IBM (software) may lead to other IT advances.

Getting the bandwidth to transport all of the data will be another problem to solve - it will most likely lead to new digital signal processing technologies, which Prof Jonas thinks will also create general applications for internet users.

Along with internet speed, another particularly pertinent problem for South Africans could be addressed by the SKA: electricity. The SKA supercomputer will use enormous amounts of power. Already there are a number of solar energy projects planned in the Northern Cape to help supply electricity to the project, and new prototypes may be developed for the site.

Prof Jonas also expects the SKA to deliver innovations in the production and design of large precision structures, including fibreglass (the material used for the telescopes) and the development of antennas, which until now has been exclusively in the domain of the military.

“While the SKA is about blue-sky science, the applications developed in the name of basic science could have a big impact on the country,” says Prof Jonas.

Dr Badat believes that the infrastructure created for the SKA - particularly in information and communication technology - and the investment in the manufacturing of the telescopes, dishes and supporting technology will go on to create local industries and many jobs in years to come.

“The SKA will be bigger than the Soccer World Cup and any future Olympics we host combined,” he predicts.