The Karoo Array Telescope

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Although the host country of the Square Kilometre Array (SKA) is yet to be announced, South African science is already reaping the benefits of the massive international radio telescope project in the form of a prototype, the Karoo Array Telescope.

"The winner in the SKA bid will only be known by 2008, but in the meantime we are planning to build the Karoo Array Telescope, or KAT, in the same region where we hope to site the core of the SKA," Dr Bernie Fanaroff, South Africa's SKA project manager, said recently.

While the KAT will only have about 1% of the SKA's receiving capacity, it will still be a powerful radio telescope in its own right. It will also prove that South Africa is ready to host the SKA and, alongside the Southern African Large Telescope (SALT), further boost the country's profile as a premier astronomy destination.

SKA shortlist

On Thursday, the International SKA steering committee in the Netherlands announced that South Africa and Australia had been shortlisted as sites for the SKA, a set of thousands of antennae that, put together, would cover a square kilometre.

The network of dishes will be at least 50 times more powerful than any telescope yet built.

SA and Australia beat bids from Argentina and China to make the SKA shortlist. A final decision is expected by 2008, while construction on the SKA will probably start in about 2013 and be completed by about 2019.

"Competition in this bid is tough, as the winning country will attract a €1-billion investment and one of the most ambitious science projects ever," Fanaroff said. "Our government recognises the power of astronomy as a tool to put South African science on the world stage and to boost development in the country."

Radio 'quietness'

In the meantime, South Africa has begun work on the KAT, with technology that will parallel that of the SKA.

Construction on this smaller version of the SKA is expected to be complete in 2008/9, and will entail cooperation with some of the other countries involved in the SKA project to ensure efficient technology transfer.

Working with the Independent Communications Authority of SA to measure radio frequency interference (RFI) levels in some of the most remote parts of SA, the South African SKA team has identified three sites in the Karoo in the Northern Cape, all three boasting radio interference-free zones of 150 kilometres, far exceeding the SKA requirement of 100km radio interference-free areas.

South Africa: ready for a new era in radio astronomy *(Image: Square Kilometre Array South Africa)*

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A radio telescope has to be as far away as possible from man-made sources of radio waves, such as cellphone and radio networks.

The Northern Cape sites also have a low topography suited to the SKA, with mountains providing extra shielding against radio waves from remote metropolitan areas. The final site will be chosen after more RFI results and infrastructure costs have been compared.

According to Fanaroff, KAT must perform first light experiments by the end of 2009.

"To achieve this, we have to move the first dishes for the full KAT array, about 20 dishes of 15m diameter each, onto site by May 2008," Fanaroff said. "By then the basic infrastructure, such as roads, electricity, water and sewage must also be in place."

Technology spin-offs

The KAT team and other contractors around the country are working towards these deadlines. While some are developing the sophisticated software and digital signal processing hardware and firmware, others are doing research to develop state-of-the-art receiver and feed systems, designing the dishes or refining the work on the selection on the physical site.

The KAT software will evolve through a series of prototypes, the first of which has to be ready for testing at the South African Astronomical Observatory in Cape Town by mid-2007.

A single 15m prototype dish to test feeds, signal processing equipment and software will be built by IST Dynamics at the Hartebeesthoek Radio Astronomy Observatory bordering the Magaliesberg mountains in Gauteng.

"This dish will not only be the test bed for all KAT components, but will also strengthen our industry's capacity to design and construct large dishes," says KAT project manager Anita Loots. "This will make it possible for South African industry to compete for contracts on SKA."

Research opportunities

According to Kim de Boer at the SKA project office in Johannesburg, there will be many opportunities for postgraduate students to get involved in the KAT project. "KAT will be commissioned in phases, and along the way we expect many exciting research opportunities to open up," De Boer says.

The South African KAT team is working closely with radio astronomy teams in Australia, the UK, Netherlands and the US. "Our collaboration with international partners will greatly reduce the cost and risks of building KAT," Fanaroff said.

The KAT project, operating under the auspices of the Department of Science and Technology, enjoys the support of several local research organisations, but the team is looking for more funding partners to make the KAT a truly world-class instrument.

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Listening to the early universe

Astronomers explore the universe by passively detecting electromagnetic radiation and cosmic rays emitted by celestial objects. The earth's atmosphere shields us from much of this radiation, so modern astronomy is done from large optical telescopes on high mountains, or from orbiting satellite observatories.

Radio astronomers, on the other hand, concentrate on the relatively long wavelength (or low frequency) radio waves that penetrate the earth's atmosphere with little impediment or distortion.

Because electromagnetic radiation travels at a fixed speed of about 1.08 billion km/h, very distant objects are observed as they were in the distant past. Astronomers are therefore able to "look back in time" to observe the early stages of the evolution of the universe.

Most existing radio telescopes were built 10 to 30 years ago. For radio astronomy to progress, a new telescope with 100 times the collecting surface of existing telescopes will be needed in about 10 years' time.

The SKA will probe the so-called "Dark Ages", when the early universe was in a gaseous form before the formation of stars and galaxies. At present, astronomers do not have the necessary tools to observe radiation from this period of the universe, which extends from about 300 000 years till one billion years after the Big Bang.

Radiation reaching us from the "Dark Ages" has travelled a huge journey through space, and is in the form of radio signals emitted by the neutral hydrogen gas that dominated the universe during this period. The signals are, however, extremely faint, and require a telescope with the planned sensitivity of the SKA to be detected.

The SKA will map the time evolution of this cosmic web of primordial gas as it condenses to form the first objects in the universe. It will also chart the development of these adolescent stars and galaxies, which will provide us with information about our own origin. The atoms in our bodies, our planet and our star were formed by the nuclear reactions that powered these early stars.

Source: Square Kilometre Array SA