Message from NSTF Executive Director

Tour to SKA with Brilliants students

Where the tour went: The NSTF Brilliants Programme (sponsored by the Fuchs Foundation) tour focused on astronomy tourism this year (*#astrotour*). It took place over six days in June 2017 and was organised and funded by the Square Kilometre Array South Africa (SKA SA) *@skasa_outreach*. We visited the following places:

- The SKA radio-telescope site near Carnarvon (more about that below)
- The South African Large Telescope (SALT) near Sutherland, where we toured both the SALT and a smaller, historically significant optical telescope, which is still used for astronomical research
- We did star gazing, taking advantage of the clear Karoo sky and the dark moon. Amateur astronomers, Edward and Lynette Forster, pointed out planets Jupiter and Saturn, fascinating stars, and the Milky Way (our galaxy), among other phenomena. We also viewed these through a conventional telescope, mounted at the Karoo Control Base of the SKA.
- The South African Astronomical Observatory (SAAO) in Cape Town, where we visited a smaller telescope (even smaller than the SALT telescope) which was used for about 100 years. It is now no longer but for outreach, in use due to light pollution in Cape Town (there is too much light to view the stars properly).
- The planetarium at the Iziko Museum, Company Gardens, Cape Town, which now has digital display for its dome (to replace the projector used for many years). Digital technology meant that we could see images in more detail. One feature video at the planetarium focused on asteroids.

During the tour, Anja Fourie, the Science Promotion Coordinator of the SKA SA, was our tour guide and very ably imparted her knowledge of the SKA, SALT, and historical details about the places we visited. We are all grateful for her role, without which we would have left with impressions only.

How the SKA radio-telescope works: (See www.ska.ac.za for more information and photographs.) The SKA is a radio-telescope, meaning that it works with radio waves of frequencies other than visible light. These waves are also the basis on which cellphones and much of our commonly-used technologies work.

The SKA receives radio waves from the universe and converts them to digital information, which is then changed to images which astronomers can study. Because of the general use of radio waves for many purposes, the SKA has to be sheltered from such radio waves and only receive signals from extra-terrestrial sources.

Building the world's largest radio telescope: "The SKA is an international effort to build the world's largest radio telescope – 100 times more sensitive than any current radio telescope. The scale of the SKA represents a huge leap forward in both engineering, and research and development, towards building and delivering a unique instrument. As one of the largest scientific endeavours in history, the SKA will bring together a wealth of the world's finest scientists, engineers and policy makers to bring the project to fruition." (From www.ska.ac.za)

The SKA is being built in stages: Initially the Karoo Array Telescope (KAT7) was built, consisting of 7 dishes, which helped South Africa to demonstrate its capability to the international SKA bid committee. The dishes of KAT7 measure 12m in diameter and, in a world first, are made entirely out of fibre glass. The KAT7 has already done observations and contributed to generating scientific knowledge.

Currently the MeerKAT radio telescope is being built: It means 'more' of the KAT initiative, as well as being the name of a small Karoo animal. It will soon consist of 64 dishes of 13.5m diameter each (this is larger than the KAT dishes). With about two thirds of the MeerKAT completed, it is already making discoveries which are impossible with other instruments.

The Brilliants students saw the KAT7 and the MeerKAT, which is being built in a valley surrounded by hills that act as a barrier to radio signals from Carnarvon and cars passing on the highway.

MeerKAT is a precursor to the complete Square Kilometre Array (SKA) telescope: The MeerKAT will be integrated into the mid-frequency component of SKA for which South Africa is responsible. 48 SKA dishes will be in the valley near Carnarvon which is approximately 1 km in diameter. The rest will be spread out throughout the Northern Cape and across another eight African countries. The longest distance between any two dishes will be 8 km.

A MeerKAT receptor dish (Photo courtesy of SKA South Africa)

About each MeerKAT receptor dish: These consist of three main components:

1. The antenna positioner, a steerable dish on a pedestal
2. A set of radio receivers
3. A set of associated digitisers

The dishes are carefully assembled onsite. The margin of error allowed while constructing them is very small, as the functioning of the dishes depends on precision of movement and stability. (Photo courtesy of SKA South Africa)

The dish is constructed to ensure excellent "optical performance, sensitivity and imaging quality, as well as good rejection of unwanted radio frequency interference from orbiting satellites and terrestrial radio transmitters…The main reflector surface is made up of 40 aluminium panels mounted on a steel support framework."

The panel composition making up the dishes is designed and manufactured in South Africa. The panels are transported to the valley and the dishes are constructed onsite.

"This framework is mounted on top of a yoke, which is in turn mounted on top of a pedestal. …The height of the total structure is 19.5 m, and it weighs 42 tons…"

"The steerable antenna positioner can point the main reflector very accurately, to within 5 arcseconds (1.4 thousandths of a degree) under low-wind and night-time observing conditions, and to within 25 arcseconds (7 thousandths of a degree) during normal operational conditions."

The dishes swivel both around and vertically (up/down) to point at any part of the sky. (Photo courtesy of SKA South Africa)

Karoo Array Processor Building (KAPB): Once the signal is converted to digital data, the digitiser sends this data via buried fibre optic cables to the KAPB. The students were treated to a tour of this building with its impressive collection of computer servers that process the masses of digital information generated by the dishes. Experts are still working on how to store the 'big data' that will eventually be captured.

A portion of the science archive data is moved off site via fibre connection and stored in Cape Town (with possibilities of reprocessing the data). Time and frequency reference signals are all synchronised to the same (atomic) clock. This is important to properly align the signals from all receptors.

The SKA has already delivered scientific results: See http://www.ska.ac.za/media-releases/meerkat-joins-the-ranks-of-the-worlds-great-scientific-instruments-through-its-first-light-image/ for images of the first discoveries.

MeerKAT is already the best radio telescope of its kind in the Southern Hemisphere. In a small patch of sky covering less than 0.01 percent of the entire celestial sphere, the MeerKAT First Light image shows more than 1300 galaxies in the distant Universe, compared to 70 known in this location prior to MeerKAT.

Dr Rob Adam, Project Director of SKA South Africa, says: "Through MeerKAT, South Africa is playing a key role in the design and development of technology for the SKA. The South African team of more than 200 young scientists, engineers and technicians, in collaboration with industry, local and foreign universities and institutions, has developed the technologies and systems for MeerKAT. These include cutting-edge telescope antennas and receivers, signal processing, timing, telescope management, computing and data storage systems, and algorithms for data processing."

Minister Naledi Pandor says: "South Africa has already demonstrated its excellent science and engineering skills by designing and building MeerKAT. This telescope, which is predominantly a locally designed and built instrument, shows the world that South Africa can compete in international research, engineering, technology and science. Government is proud of our scientists and engineers for pioneering a radio telescope that will lead to groundbreaking research."

MeerKAT is funded by the South African Government and is a South African-designed telescope with 75% of its value sourced locally.

Read the popular newsletters or technical newsletters of the SKA: An interesting edition of the latter is: http://www.ska.ac.za/wp-content/uploads/2016/12/ska_sa_tech_news_01.pdf

The Global Information System (GIS) for South Africa and other African countries is still done in South Africa, and was taken over two years ago by GIS specialist Tshegofatso Monama, who works at SKA SA's Johannesburg office. (Tshego Monama used to be a member of the NSTF office staff).