MeerKAT AR1

ARRAY RELEASE 1
INFORMATION SHEET

science & technology
Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA

NRF National Research Foundation

SKA Africa

SKA AFRICA
SQUARE KILOMETRE ARRAY

MeerKAT joins the ranks of the world's great scientific instruments through its **First Light image**

IMAGE 1: MeerKAT First Light image. Each white dot represents the intensity of radio waves recorded with 16 dishes of the MeerKAT telescope in the Karoo (when completed, MeerKAT will consist of 64 dishes and associated systems). More than 1300 individual objects - galaxies in the distant Universe - are seen in this image.

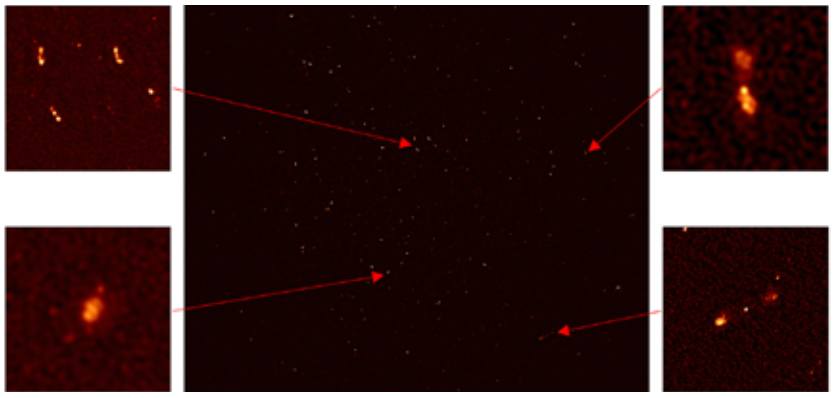


IMAGE 2: Montage of MeerKAT First Light radio image and four zoomed-in insets. The two panels to the right show distant galaxies with massive black holes at their centers. At lower left is a galaxy approximately 200 million light years away, where hydrogen gas is being used up to form stars in large numbers.

The MeerKAT First Light image of the sky shows unambiguously that MeerKAT is already the best radio telescope of its kind in the Southern Hemisphere.

Array Release 1 (AR1) provides 16 of an eventual 64 dishes integrated into a working, fully functional telescope array. It is the first significant scientific milestone achieved by MeerKAT, the radio telescope under construction in the Karoo that will eventually be integrated into the Square Kilometre Array (SKA).

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.

MeerKAT will consist of 64 receptors, each comprising a 13.5-metre diameter dish antenna, cryogenic coolers, receivers, digitiser, and other electronics. The commissioning of MeerKAT is done in phases to allow for verification of the system, early resolution of any technical issues,

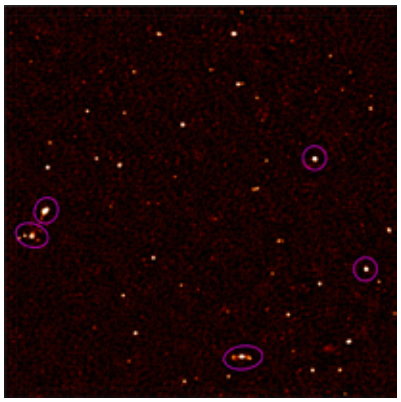


IMAGE 3: View showing 10% of the full MeerKAT First Light radio image. More than 200 astronomical radio sources (white dots) are visible in this image, where prior to MeerKAT only five were known (indicated by violet circles). This image spans about the area of the Earth's moon.

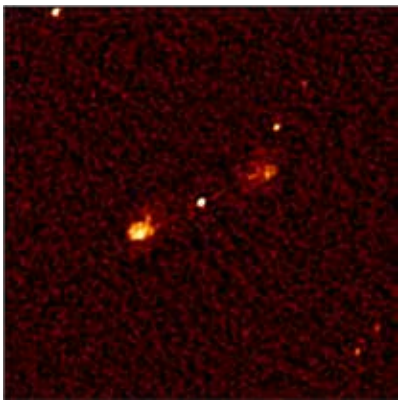
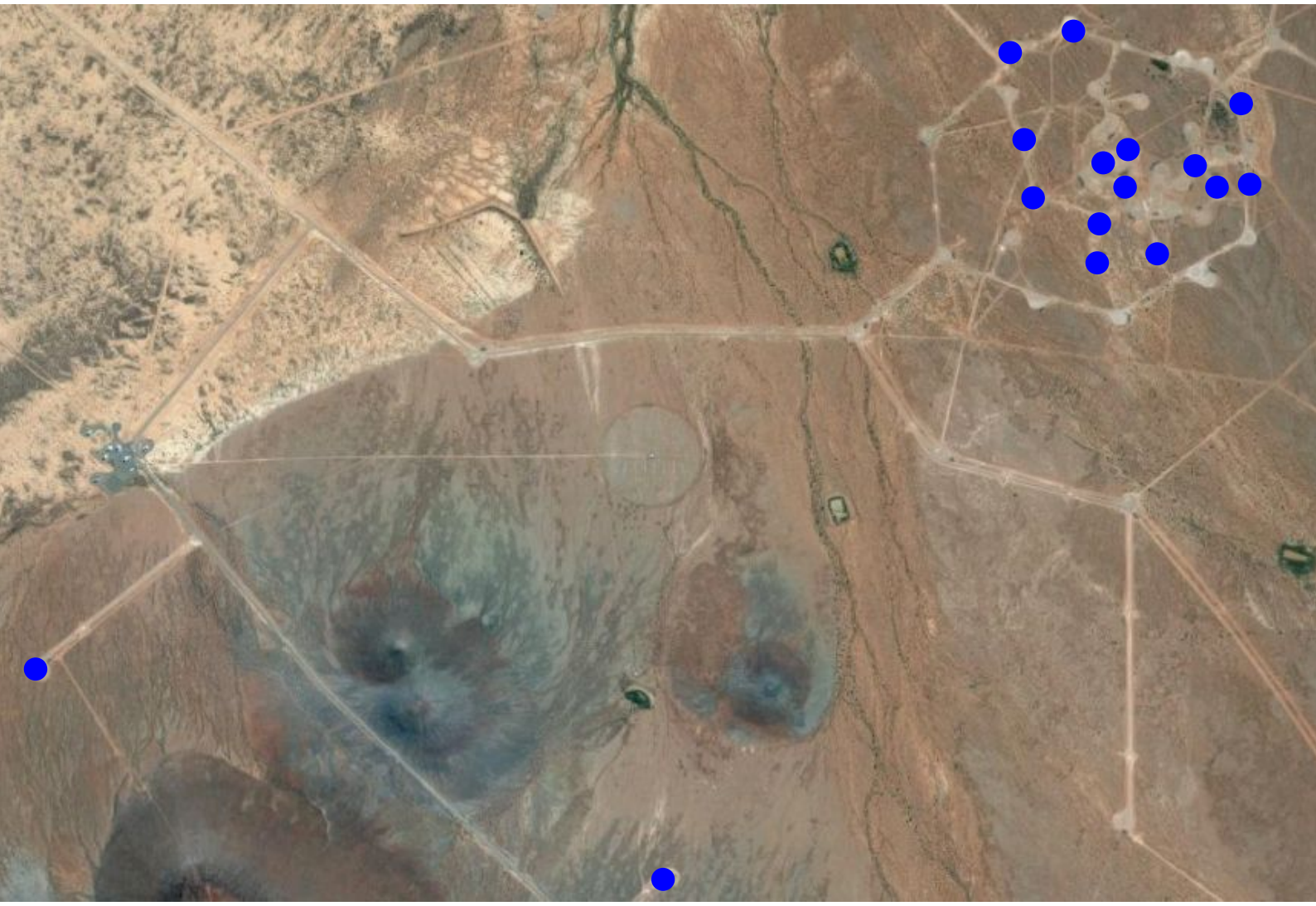


IMAGE 4: Higher-resolution version of lower-right panel in IMAGE 2. This view, covering about 1% of the full MeerKAT First Light image, shows a "Fanaroff-Riley Class 2" (FR2) object: a massive black hole in the distant Universe (matter falling into it produces the bright dot at the center) launching jets of powerful electrons moving at close to the speed of light that emit radio waves detected with MeerKAT's sharp view of the radio sky (thin lines connecting the central dot to the brighter lobes of radio emission).

The Karoo site



The location of the 16 AR1 antennas at the SKA SA site at Losberg in the Karoo.

MeerKAT First Light image

Observational setup

- Pointing is a commissioning field 10 degrees from the South Celestial Pole
- 16 antennas, 4096 channel correlator mode
- Observation on 2016-06-19 from 04:00 to 16:00 UCT
- 7.5 hours on source after calibration overheads

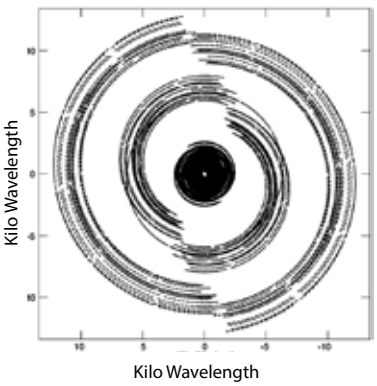
Calibration

- Data were “flagged” over full frequency range (900-1670 MHz) after masking known satellite bands
- Gain variation per antenna is less than 10% in amplitude and 10 deg in phase over the course of the observation

Imaging

- Image made using Multi-Frequency Synthesis with entire available band, centre frequency is 1284 MHz
- Image made with uniform weighting has resolution of ~7 arcseconds
- Image rms noise level ~12 micro Jy
- Image contains >1300 sources to 5 sigma limit

UV coverage



FIRST LIGHT IMAGE SHOWS MORE THAN **1300 galaxies** COMPARED TO ***70 known*** IN THIS LOCATION PRIOR TO MEERKAT

AR1 = 16 of an eventual 64 DISHES

AR2 = 32 of an eventual 64 DISHES

MeerKAT = 64 RECEPTORS

75% of MeerKAT's value sourced LOCALLY, SA DESIGNED

and initial science exploitation. Early science can be done with parts of the array as they are commissioned, even as construction continues. AR1 consists of 16 receptors, AR2 of 32 and AR3 of 64, expected to be in place by late 2017. Given the performance of AR1 so far, when completed MeerKAT will be the best telescope of its kind in the world.

MeerKAT is a precursor to the Square Kilometre Array (SKA) and follows the KAT-7 telescope which was an engineering test-bed for MeerKAT. MeerKAT is funded by the South African Government and is a South African designed telescope with 75% of its value sourced locally. MeerKAT also represents a sizeable international research and development investment for South Africa.

MeerKAT will be an integral part of SKA Phase 1. An important aspect of the SKA site decision in 2012 was that MeerKAT would be part of the sensitive SKA Phase 1 array, which will be the most sensitive radio telescope in the world.

Upon completion at the end of 2017, MeerKAT will consist of 64 dishes and associated instrumentation. SKA1 MID will include an additional 133 dishes, bringing the total number for SKA1 MID to 197.

The SKA is an international effort to build the world's largest radio telescope - one hundred times more sensitive than any current radio telescope. The vast amounts of data to be obtained with SKA - one of the world's leading Big Data experiments - is encouraging significant research and development in digital signal processing, data storage, and analysis techniques that may have broader applications.

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. SKA will be built in two phases - SKA1 and SKA2 - starting in 2018. SKA1 will include two components - SKA1 MID (to be built in South Africa) and SKA1 LOW (to be built in Australia); they will observe the Universe at different radio frequencies.

MeerKAT Science

Observing time on MeerKAT for five years is open to the international community and is being allocated according to the following ratios: 70% for large survey projects of 1000 hours or more and 30% for smaller PI driven proposals. 5% will be Director's discretionary time.

The MeerKAT Large Survey Projects which have already been allocated time:

Radio Pulsar Timing: Testing Einstein's theory of gravity and gravitational radiation - Investigating the physics of enigmatic neutron stars through observations of pulsars.

LADUMA (Looking at the Distant Universe with the MeerKAT Array) - An ultra-deep survey of neutral hydrogen gas in the early Universe.

MeerKAT Absorption Line Survey for atomic hydrogen and OH lines in absorption against distant continuum sources (OH line ratios may give clues about changes in the fundamental constants in the early Universe).

MHONGOOSE (MeerKAT HI Observations of Nearby Galactic Objects: Observing Southern Emitters) - Investigations of different types of galaxies; dark matter and the cosmic web.

TRAPUM (Transients and Pulsars with MeerKAT) - Searching for and investigating new and exotic pulsars.

A MeerKAT HI Survey of the Fornax Cluster (Galaxy formation and evolution in the cluster environment).

MIGHTEE (MeerKAT International GigaHertz Tiered Extragalactic Exploration Survey) - Deep continuum observations of the earliest radio galaxies.

ThunderKAT (The Hunt for Dynamic and Explosive Radio Transients with MeerKAT) - for example gamma ray bursts, novae and supernovae, plus new types of transient radio sources.