First Results from MeerKAT Commissioning Observations

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MeerKATHI group & MeerKAT commissioning team @ SKA-SA
The MeerKAT telescope

- Antennas & Baselines:
  - 64 antennas, 13.5-m diameter
  - Longest baseline 8000 m. + Dense core of baselines < 50 m.
  - $T_{\text{sys/efficiency}} = 22$ K at 1.4 GHz

- Spectral information:
  - Bandwidth: 0.9–1.67 GHz (HI $0<z<0.58$) + UHF + S-band
  - Wideband mode: $\sim 20$kHz $\sim 5$ km/s (32K channels)
  - Zoom Mode: 0.1 km/s
MeerKAT: the SKA precursor

- MeerKAT has ~ 2000 baselines
  - Extreme UV-coverage
    - Simultaneous A,B,C,D and E VLA configurations.
    - High sensitivity uniform throughout all angular scales
  - S/N $\sim 10^4 \rightarrow$ SKA regime.

- MeerKAT has small antennas
  - Large F.O.V.
  - Primary beam sensitivity drops only beyond 1 degree.
  - Great to image Fornax A and HI in nearby galaxies
  - Issues with point source calibrators: other bright sources in the field

Image Credit: Disney
The MeerKAT Fornax Survey

- Observe the Fornax Cluster and the group of Fornax A with MeerKAT
  - 900 hours to observe 12 deg²

- Science goals (see Paolo Serra’s Talk)
  - Study the phenomena of gas removal and accretion in galaxies.
    - Sensitivity in neutral hydrogen $N(\text{HI}) \sim 10^{19}$ cm$^{-2}$ at 1 kpc resolution
    - Identify and investigate the neutral hydrogen low column ICM.
  - Sensitivity in neutral hydrogen $N(\text{HI}) \sim 10^{18}$ cm$^{-2}$ at 10 kpc
  - Determine the HI mass function down to $M(\text{HI}) \sim 5 \times 10^5$ $M_{\odot}$
The Meerkat Fornax Survey

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*People present at this workshop*
Observations in the Fornax Cluster

NGC 1399 & Fornax A
Channels: 4096 - SKARAB4K
Channel width: 209 kHz - 45 km/s
Frequency range: 1400 - 1420 GHz
Integration time: ~ 8 hours

Data reduction — MeerKATHI pipeline
Image Credit: M. Ramatsoku
MeerKATHI

- **MeerKATHI**: end-to-end data reduction pipeline for interferometric observations.
  - Source accessible and easy to change
  - Make use of any best available software, thanks to Stimela [Makhatini et al. 2016]
  - Portable
  - Easy to Install
  - Scalable (working for large data sets in distributed environment)
  - **Will be public**

MeerKATHI group:

- S. Makhathini (RATT), B. Hugo (SARAO/RATT), K. Thorat (RATT), **F. Maccagni (OAC)**, E. de Blok (Kapteyn/ASTRON/UCT), **P. Serra (OAC)**, A. Ramaila (SARAO), **M. Ramatsoku (OAC)**, G. Józsa (SARAO, Rhodes, Bonn), P. Kamphuis (Bochum), O. Smirnov (SARAO/RATT), **D. Kleiner (OAC)**, **D. Molnar (OAC)**
NGC 1399

Noise = 30 $\mu$Jy

$S_{\text{peak}}$ (NGC1399) = 30 mJy

$S_{\text{peak}}$ (MRC0336-355) = 480 mJy

$S$ (MRC0336-355) / $N$ ~ 1.3 x 10$^4$
NGC 1399
NGC 1399: MeerKAT vs VLA

- Diffuse emission easily picked up.
- New insights about the evolution history of the AGN in NGC1399?
- More point sources detected in the field
MeerKAT spectral line data

- NGC 1427A: giant neutral hydrogen (HI) disk in a tidal interaction [Lee-Waddell et al. 2017]

- Yellow: HI detected by ATCA
  - Beam: 86’’x56’’
  - Lowest contour: $5 \times 10^{19} \text{ cm}^{-2}$

- Red: HI detected by MeerKAT
  - Beam: 32’’x 25’’
  - Lowest contour: $4 \times 10^{19} \text{ cm}^{-2}$

- MeerKAT observation indicate a tidal interaction rather than ram pressure stripping, as previously hinted by ATCA.
Fornax A

Noise = 40 µJy

$S_{\text{peak}} (\text{Fornax A}) = 116 \text{ mJy}$

Most of flux in the LOBES
Fornax A
Fornax A: MeerKAT vs VLA

- **MeerKAT** [Maccagni et al. in prep.]
- **VLA** [Fomalont et al. 1989]

- Much more detail in the lobes
- No more Y-shaped sources
- Good imaging of sources around Fornax A, and behind the lobes.
Fornax A: MeerKAT vs VLA

- **MeerKAT** [Maccagni et al. in prep.]
- **VLA** [Fomalont et al. 1989]

- Much more detail in the lobes
- No more Y-shaped sources
- Need of DDC for some sources
Fornax A: MeerKAT vs VLA

- **MeerKAT** [Maccagni et al. in prep.]
- **VLA** [Fomalont et al. 1989]

- Good imaging of sources around Fornax A, and behind the lobes.
- The full information is contained in the spectral line data cube.
The goal of the MFS is to detect low column density HI in the Fornax cluster.

- **Red**: 1.4 GHz continuum
- **Background**: FDS survey, r-filter [Venhola et al. 2017].
- **Cyan**: HI detections from MeerKAT observation (1.40-1.41 GHz).
Commissioning Observations: Circinus

- Closest (4 Mpc) spiral galaxy with a Seyfert 2 nucleus
- $M_* = 9.5 \times 10^{10} M_{\text{sun}}$
- $M (\text{HI}) = 9 \times 10^9 M_{\text{sun}}$
- $D (\text{HI}) = 70''$
- MeerKAT 1.4 GHz continuum

Image Credit: J. Josza

ATCA [Elmouttie et al. 1998]
Circinus: spectral line data

Credit: Thorat, Josza
Commissioning Observations: Circinus

Credit: Thorat, Josza
Conclusions

- MeerKAT observations can be reduced via an automated pipeline.
- MeerKAT commissioning observations show promising results:
  - Radio continuum imaging.
    - Wide f.o.v. at high resolution and dynamic range (LOFAR at 1.4 GHz)
  - Spectral line observations.
    - High resolution (10") observations of nearby HI rich radio galaxies.
- MeerKAT will change our view of the radio sky.