

**Title:** MeerKAT(+) and Euclid Team up: a multi-wavelength galaxy evolution study

**Supervisor:** Dr Lucia Marchetti

**Co-Supervisor:** Dr Ros Skelton (SAAO), Dr Isabella Prandoni (INAF-IRA)

**Abstract:**

Galaxies are thought to emerge at the centre of dark matter (DM) halos (Silk & Mamon 2012), forming stars in a way connected to the growth of such halos (so-called galaxy–halo connection). On the micro-scale, supermassive black holes (SMBH) accrete gas and grow tightly connected to the properties of the host galaxies (Kormendy & Ho 2013). Feedback processes within galaxies may impact their surroundings, influencing future gas accretion and star formation (SF). Feedback from radio-loud AGN, in particular, is often invoked to explain the observed properties of massive galaxies in the local Universe. Less clear is the role of jet-induced feedback at higher redshifts ( $z \geq 1$ ), where radio-AGN activity shifts towards lower-mass, mostly star-forming galaxies (SFG; Smolcic+17). Shedding light on the interplay between SMBHs, galaxies and DM halos at the peak epoch of cosmic assembly ( $1 < z < 3$ ; the ‘cosmic noon’), requires observations over large cosmological volumes to probe all environments and include the rarest galaxy/AGN populations, while also being gas/dust-insensitive to unveil the dominant contribution of obscured AGN and SF activity (Dunlop+2017; Vito+2018). Deep radio–continuum surveys provide a unique tool to reach an unbiased census of SFG and radio AGN (Prandoni & Seymour 2015). Euclid and eventually, the Vera C. Rubin, on the other hand, will provide an unprecedented view of the large-scale structure up to cosmic noon and beyond, as well as a direct estimate of the DM halo mass and distribution around galaxies. In this project, we aim to combine MeerKAT, Euclid and other multi-wavelength observations to study these processes.

**Project outline:**

Galaxies are thought to emerge at the centre of dark matter (DM) halos (Silk & Mamon 2012), forming stars in a way connected to the growth of such halos (so-called galaxy–halo connection). On the micro-scale, supermassive black holes (SMBH) accrete gas and grow tightly connected to the properties of the host galaxies (Kormendy & Ho 2013). Feedback processes within galaxies may impact their surroundings, influencing future gas accretion and star formation (SF). Feedback from radio-loud AGN, in particular, is often invoked to explain the observed properties of massive galaxies in the local Universe. Less clear is the role of jet-induced feedback at higher redshifts ( $z \geq 1$ ), where radio-AGN activity shifts towards lower-mass, mostly star-forming galaxies (SFG; Smolcic+17). Shedding light on the interplay between SMBHs, galaxies and DM halos at the peak epoch of cosmic assembly ( $1 < z < 3$ ; the ‘cosmic noon’), requires observations over large cosmological volumes to probe all environments and include the rarest galaxy/AGN populations, while also being gas/dust-insensitive to unveil the dominant contribution of obscured AGN and SF activity (Dunlop+2017; Vito+2018). Deep radio–continuum surveys provide a unique tool to reach an unbiased census of SFG and radio AGN (Prandoni & Seymour 2015). Euclid and Vera C. Rubin,

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Euclid Deep Fields will represent the premier extra-galactic deep fields for the next decade and beyond, as it also represents one of the Deep Drill field for the Vera C. Rubin observatory, and MeerKAT(+) is the only current radio telescope that can conduct deep surveys of the Euclid Deep Field South (EDFS). The long-term plan is to exploit MeerKAT+ (MK+) to carry out an ultra-deep radio survey of this area. Joint MeerKAT(+)/Euclid/Vera C. Rubin analysis of the EDFs will shed light on the complex interplay between SMBHs, galaxies and DM halos at cosmic noon, by enabling statistically robust, multi-variate and transient studies of the various galaxy/AGN populations. The EDFs survey will probe enough cosmological volume to maintain the effect of sample variance  $\lesssim 10\text{--}20\%$  up to stellar masses  $\sim 10^{11}\text{--}12 M_{\odot}$  (Jarvis+2015) or DM halo masses ( $\lesssim 10^{14} M_{\odot}$ ).

In preparation for the MK+ survey ( $\geq 2025$ ), an observing program of 118h has been carried out with MeerKAT (MK) to provide a first shallower (rms  $\sim 6 \mu\text{Jy/b}$ ) coverage of the entire EDFs at L-band. The MK observations were carried out over the period December 2023 – February 2024. The data reduction of the continuum data is at an advanced stage, and final radio mosaics will be available by the start of this project in 2026.

With this project, the student we'll have the opportunity to join the EDFs international team as well as the Vera C. Rubin collaboration (as JA under Dr Lucia Marchetti's SA PI-ship). Within the team, he/she will contribute to the Radio data product validation that will be carried out at the start of the MSc in collaboration with the INAF team. The student will then focus on compiling the best multi-wavelength dataset to characterise the sources and explore the interplay between star formation and AGN activities by exploiting multi-wavelength photometric and spectroscopic diagnostics. We will start by characterising the X-ray properties of the X-ray-detected galaxies and comparing them with the Radio properties to constrain the typical nuclear activity of the galaxies under analysis. We will then characterise star formation and AGN activity in galaxies by analysing their broadband spectral energy distributions (SEDs).

In this project, we thus aim to make use of the first set of Euclid public (and private via the Euclid collaboration) data, which will be used for the classification of our sources. By putting together Euclid, MeerKAT and other available data in the field, we will provide a multiwavelength characterisation of the sources, which will also provide a benchmark for the Vera C. Rubin observations in the field.

Finally, this project will also benefit (e.g. travel funding) from the existing ISMOS exchange program between INAF (where Dr Isabella Prandoni, co-supervisor of this project, is based) and South Africa via SARAO. It will also strengthen the collaboration between INAF and SAAO (Dr Rosalind Skelton, SAAO Managing Director, is a co-supervisor in this project) in the context of the Vera C. Rubin collaboration.