SARAO Application for Supervisors to Propose Research Projects

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Short abstract:

We have already witnessed the extraordinary sensitivity of MeerKAT to faint radio emission, and in this project we will exploit this for studying large samples of 'radio-quiet' active galaxies. These are galaxies where material is accreting onto the central supermassive black hole, but, for some reason, they do not produce powerful radio jets. Therefore, they are traditionally very difficult to detect in the radio, and so are poorly studied (despite composing over 90% of the active-galaxy population). These objects still produce low levels of radio emission, but by what physical process? Could our assumption (held for decades), that it is mostly due to star formation, be wrong? And if so, does the process involved have an impact on the surrounding host galaxy? These are questions we hope to answer with this project.

Section A: Overview of the Research Project Proposal

1. Academic level of research project: Masters

2. Broad field of research: Astronomy/Astrophysics

3. Title of the research project: **A MIGHTEE investigation into 'radio-quiet' AGN**

4. Supervisors: Prof Oleg Smirnov, Dr Sarah White

5. University for student registration: Rhodes University

Section B: Research Project Proposal

1. Scientific merit:

MeerKAT is the mid-frequency precursor telescope to the Square Kilometre Array (SKA), and provides excellent sensitivity that allows us to detect sources with very faint radio emission. This includes 'radio-quiet' active galactic nuclei (AGN), which are supermassive black holes that accrete material and produce low levels of radio emission. These black holes reside in host galaxies, whose star-formation processes are thought to be the origin of this emission, but recent work on radio-quiet quasars (RQQs; a subset of AGN) argues that the black-hole accretion process is actually what dominates [White et al. (2015) -- https://arxiv.org/abs/1410.3892, White et al. (2017) -- https://arxiv.org/abs/1702.00904]. In this project, we will investigate the significance of this accretion component, including its fraction of the total emission across *all* faint radio sources (i.e. normal star-forming galaxies, without an accreting black-hole at the centre, in addition to RQQs). This is crucial and hotly-debated research, as it is currently expected that the *total* radio emission of such sources can be used to determine the star-formation history of the Universe [one of the key science goals of the SKA; Jarvis et al. (2015) -- https://arxiv.org/abs/1412.5753]. In addition, determining the mechanism that gives rise to the radio emission in 'radio-quiet' AGN allows us to understand what feedback processes may be present, and what this entails for the level of star formation within the host galaxy [McAlpine et al. (2015) -- https://arxiv.org/abs/1412.5771]. Furthermore, by making comparisons with matched samples of 'radio-loud' AGN, we may finally be able to uncover why it is that some galaxies produce powerful radio-jets whilst the majority do not – a question that has plagued galaxy-evolution research for decades.

2. Feasibility:

This project will exploit in-hand radio data from MeerKAT International GHz Tiered Extragalactic Exploration (MIGHTEE) survey, and the wealth of multi-wavelength data that is already available over the MIGHTEE fields. Firstly, we will make use of pre-existing information from photometric-fitting code to define and refine our sample of radio-quiet quasars, and also a 'control' sample of star-forming galaxies for comparison. At the positions of the sources, as identified in the optical/near-infrared data, we will then measure the radio emission and investigate what fraction of this is related to star formation and how much is related to black-hole accretion. For example, we can use existing far-infrared data to determine an independent measure of the star-formation rates for individual sources, and compare these values to those derived through the deep radio-data. By the end of January 2020 we will also have new optical spectroscopy from the Southern African Large Telescope (PI: White). This will allow the student to determine accurate redshifts for the quasars, giving her/him experience in optical astronomy as well as radio astronomy. The work described so far should take up to 10 months, and if the student started in January 2020, they should have results ready for presentation at the 2020 SARAO Postgraduate Scholarship Conference. The next 10 months will concern investigating the exact mechanism that gives rise to the radio emission associated with black-hole accretion. For this we will explore how this component of the radio emission varies with other properties of the quasar, as measured through optical and X-ray observations. There will also be the opportunity to obtain follow-up radio data using very-long-baseline interferometry (VLBI), for spatially resolving the (compact) radio emission associated with the accretion process from the (more-diffuse) radio emission associated with star formation. The final four months of the two-year project are allocated for the student to write up their research, with at least one paper also expected to result from their work.

3. Links of the project to one or more of the SARAO research priority areas:

This project will use radio data obtained as part of the MIGHTEE survey, which is one of the Large Survey Projects on MeerKAT. The main research area driving this survey is galaxy evolution, and specifically how star formation and black-hole accretion evolve in/over extragalactic sources detected out to high redshift ($z \sim 4$). The sensitivity of MeerKAT is required to reach such depths in a reasonable amount of time, and to form a complete census of the different types of star-forming galaxy and active galaxy that exist. This project is concerned with active galaxies that are 'radio quiet', and are very poorly-studied due to the relatively low levels of radio emission that they produce. It is thanks to MeerKAT that we will finally be able to study large samples of these objects for the first time, *and* whether/how they have evolved over the past 12 billion years (i.e. over 4/5 of the time since the Big Bang).

4. Student requirements:

For this work, the student is expected to have an undergraduate background in physics and/or astronomy, preferably with a good understanding of statistical methods. Previous programming experience is necessary, with knowledge of Python being highly desirable.