Observing Comets In The Solar System With MeerKAT

2. Research category: **Science**
3. Academic level: **PhD**
4. Primary supervisor:

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6. Abstract: Radio observations of OH 18 cm lines are an established tool for assessing the total water production rate in comets (see e.g. Crovisier et al, 2002). The OH emission is a weak maser, pumped by solar UV radiation. Doppler shift due to the orbital motion of a comet with respect to the Sun can produce both inversion and anti-inversion of the OH levels, leading to absorption or stimulated emission (against the radio sky background). The sensitivity and angular resolution of MeerKAT enable detailed cometary observations, which here will be combined with the atmospheric models and other ground-based and space observations of comets to provide

Details of Research Project

1. Scientific merit: Comets are thought to have formed in the outer solar system. Subsequently, their orbital motions were perturbed to bring them onto highly elliptical orbits and thus occasionally very close to the Sun and Earth. Given their origin and the fact that even in elliptical orbits, comets spend most of their lifetime in the cold outer solar system, they are relatively unprocessed, primordial bodies, their study providing diagnostics for, e.g., conditions for forming planetesimals far from the Sun. When passing a perihelion, the strong illumination causes the comet's volatile materials to vaporize and stream out of the nucleus, carrying dust away. In-situ data from the comets was limited to several flyby missions, until ESA's Rosetta mission followed comet 67P from before to after its perihelion in 2015, providing unprecedented details of a comet from the close-up perspective. Another milestone in in-situ cometary exploration is approaching: ESA's Comet Interceptor mission, which will target a (yet undiscovered) comet with a highly elliptical orbit. The Comet Interceptor is to be launched in 2028, so the research into the physics of comets will be highly topical in the upcoming years. The interest in comets is further enhanced by the fact that two of the three interstellar objects discovered to date are comets. With the advent of automatic survey facilities, the rate of discoveries of cometary objects will be highly increased.

In this thesis project, the candidate will work with cometary observations made by MeerKAT to date, engage with cross-disciplinary studies and modelling. The candidate will also work with planning potential new observations of comets.

This is a science project that utilises existing MeerKAT data. (focus area 4.1).

2. Feasibility: Cometary observations have been carried out by MeerKAT on a number of occasions.

In 2021 the 67P comet (Churyumov-Gerasimenko) was observed by MeerKAT around its perihelion pass. Comet 67P has been extensively studied by the ESA Rosetta spacecraft around the 2015 perihelion. A number of observing sessions were dedicated to 67P, which are currently being analyzed by one of the supervisors.

In October 2025, MeerKAT conducted successful observations resulting in the detection of OH in 3I/ATLAS, the third interstellar object ever discovered. This has resulted in two detection notices (ATels) and a paper currently in preparation. MeerKAT observed 3I/ATLAS on ten follow-up occasions in 2025.

Subsequently, comets C/2025 A6 (Lemmon) and C/2024 E1 Wierzchos were also observed in November-December 2025.

The PhD candidate will conduct a detailed analysis of the data, and will engage in future observations of comets. For example, comet 67P will return for its next perihelion in early 2028, within the period of the candidate's PhD studies, and would be exciting to study, being the most closely researched comet to date.

3. Skills development: Describe the skills the student will develop from the research project.

The candidate will learn radio interferometric theory and techniques, and MeerKAT data processing. The candidate will also learn the physics of comets, and how radio astronomical observations can contribute to the challenges in solar system studies.

4. Provide details (and confirmation) on the availability of required data / access to required equipment / availability of research facilities and other resources required.

MeerKAT observations of a number of comets are already available (see above). The full resources of the RATT compute cluster, as well as the iliu facility, are available to support this project.

5. Include expected milestones and associated time frames towards attaining the overall objectives of the project.

We expect the student to familiarize with the specific techniques used in the analysis of cometary OH 18 cm line observations during the first six months. One of the supervisors has extensive experience with the reduction of MeerKAT zoom mode data. In parallel, the student will learn about planning the cometary observations – with the considerations of maser pumping conditions, expected cometary outgassing and visibility constraints. In the following year (months 7-13), the student will prepare publications based on the data available at the start of the project, and propose and conduct new observations. Interpretations and cross-disciplinary studies will constitute the remaining part of the project.

6. Qualifications, academic abilities, skills and/or experience that a student should have in order to successfully deliver on the objectives of the research proposed.

Familiarity with radio interferometry and solar system physics would be advantageous but not required.

Supervisor

Oleg Smirnov 27 February 2026