Developing novel algorithms and approaches for beamforming and pulsar searching in the SKA era

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Description: Fundamental physics with pulsars is a headline science theme for the Square Kilometre Array (SKA) project, the ultimate radio telescope to be ever built. As such, a full cosmic census of the Galactic pulsar population is a key science driver for Phase 1 SKA; in particular, searching for pulsars in close binary systems and exploiting them for performing exquisite tests of the theories of gravity, including Einstein's theory of relativity, is a high-priority science objective for the SKA and its pathfinder/precursor facilities. At the low radio frequencies in which the SKA-Low is designed to operate (i.e. below ~300 MHz), sensitive searches for such exotic objects continue to be a daunting computational challenge, owing to a large multi-dimensional search parameter space, and inherently large computational costs for beamforming and processing.

The main objectives of the project include:

- Undertaking a systematic exploration of new hybrid beam-forming techniques and their applications for high-sensitivity pulsar searches in low-frequency high-time-resolution data obtained from the MWA telescope.
- Developing an end-to-end processing pipeline that can be deployed on high-performance supercomputers to facilitate intensive searches for binary pulsars in tight orbits where the relativistic effects are significant.
- Application of the newly-developed software pipelines to perform a pilot survey of select parts of the sky (e.g. ~3000 square degrees), to search for such binary pulsar systems and make the first discoveries of such exotic objects with the MWA.

Successful demonstration of such novel algorithmic approaches and their viability in low-frequency searches will not only accelerate the processing efforts needed to realise the SMART survey's science goals, but will also provide valuable insights into designing optimal survey and beamforming strategies that are relevant for the SKA and its pathfinder facilities such as the South African MeerKAT. From a scientific perspective, the discovery of even a single object of this rare class will be a significant addition to the small sample (~10) of targets that are highly sought after for advancing our knowledge of fundamental physics (e.g., strong-field gravity), thus pushing the frontiers of physics and preparing for science planned with the SKA.
This project is ideal for a candidate with a sound background in physics or astrophysics, and a strong inclination for software development and signal processing aspects of radio astronomy. A background in radio astronomy with some research experience is an additional advantage.