1. Title of research project: Closure phase analysis of HERA data

2. Academic level: Msc

3. Supervisor's title and full name: Prof. Oleg M. Smirnov

4. Co-supervisor's title and full name: Prof. Gianni Bernardi

5. Supervisor's university: Rhodes University

6. Overview and aims of the research project (maximum 300 words):
Our current understanding of the cosmic evolution from the epoch of Hydrogen recombination till the first billion years is very poorly known from an observational perspective, although it must have seen the growth of the initial density perturbations via gravitational attraction into the first stars and galaxies.
The 21-cm transition from neutral Hydrogen promises to be the best observational probe of this cosmic time and has driven the construction of the new generation of low frequency radio arrays including the HI Epoch of Reionization (EoR) Array (HERA) currently under construction in the Karoo.
The main difficulty in measuring the 21-cm signal is the subtraction of bright foregrounds that requires a very accurate interferometric calibration. Carilli et al. (2018) have recently suggested to mitigate the calibration and foreground subtraction requirements by using visibility closure phases that are immune to calibration errors. The candidate will be applying this technique to HERA data, pushing it as far as possible towards a detection of the 21-cm signal or a systematic-limited upper limit.
An ideal candidate will have a good background in physics and mathematics, the willingness to learn about advanced radio interferometry, statistics, signal processing techniques and cosmology, but, mostly, the desire to contribute to the 21-cm cosmology revolution.

7. Relevance of the research proposed to the priority areas of MeerKAT and / or SKA refer to the application guide (maximum 200 words):
This project is part of the “Epoch of Reionization and Intensity Mapping data reduction and analysis” research area and has a significant connection with the “Interferometric Data Processing and Analysis, including calibration and imaging” research area. It uses data from one of the Karoo telescopes (HERA) that is an SKA precursor and has a significant South African partnership (through SKA SA and various SA universities).

8. Research work breakdown:

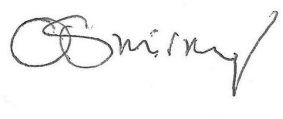
a. Research work structure for Year 1.
HERA is now well underway with 80+ dishes (and counting) under construction and commissioning is continuing as the array grows, with the first scientific results already appearing (e.g., Kohn et al. 2018, Carilli et al. 2018). Our group has been involved in the analysis of HERA

data, in particular by producing the first all-sky images, developing an advanced calibration method (Grobler et al. 2018) and investigating foreground subtraction methods (Ghosh et al., in prep.).
In its first year, the candidate is expected to learn the principles of radio interferometry, with particular focus on the relevant 21-cm techniques like closure phase analysis, interferometric calibration and power spectrum estimation.

b. Research work structure for Year 2.
During its second year, the candidate is expected to apply the closure phase analysis on HERA data in order to set an upper limit to the 21-cm signal or - ambitiously - a detection! In particular, the candidate may focus on the low frequency (< 100 MHz) HERA data in order to confirm the recent claim of a global signal detection at 78 MHz (Bowman et al. 2018). This signal was found twice as bright as the most optimistic models, sparkling a huge number of interpretations that require exotic physics (e.g., Barkana et al. 2018). If the signal is indeed so bright, HERA is the best telescope to confirm it and the closure phase technique may be effective at low frequencies, where calibration and foreground subtraction are even harder. Even a meaningful upper limit will grant a thesis with distinction.

9. Availability of required data / access to required equipment / availability of research facilities and other resources required (maximum 200 words):
The co-supervisor is one of the HERA co-PIs and has full access to the HERA data. The student will have the same rights. The Radio Astronomy Technologies and Techniques (RATT) group established at Rhodes maintains a cluster consisting of 8 “fat” nodes (512GB RAM, 16-48 CPUs per node) with plenty of attached storage. This has, so far, supported a variety of efforts, including the analysis of PAPER and HERA data. The student will have access to this cluster, which is entirely adequate for the proposed project.

10. Signature of supervisor and date of proposal submission



31 August 2018