Overview of the research proposal

1. **Academic level:** PhD
2. **Broad field of research:** Astronomy/astrophysics
3. **Title of research project:** A MeerKAT measurement of the HI galaxy velocity function out to z=0.5.
4. **Research project abstract:**

This project will focus on having a student combine neutral atomic hydrogen (HI) observations from the LADUMA (Looking At the Distant Universe with the MeerKAT Array) large survey project with state-of-the-art numerical simulations in order to determine the reliability with which dynamical measurements of galaxies can be extracted from the LADUMA data. This will be done by applying and testing source-finding methods to the real and the simulated data imaged with various smoothing and weighting schemes. Accurate dynamical measurements will be used to study the distribution of galaxy velocity widths out to $z \approx 0.5$. The results will be compared to theoretical predictions in order to glean important insights into the formation and evolution histories of galaxies.

Supervisor details

1. Primary supervisor's details:

a. **Title and full name:** Dr Edward Elson
b. **Name of university:** University of the Western Cape
c. **Email address:** drelson.e.c@gmail.com
d. **Supervision of postgraduate students:**

PhD students: I've not been the primary supervisor of a PhD student.

Masters students:

Name of student	Nationality	Date started degree	Date completed/ will complete	Title of research project	Co-supervisor
Unarine Tshiwawa	SA	July 2017	Dec 2018	A study of the angular momentum content of early-type galaxies	Prof. Roy Maartens
Modisha Tladi	SA	July 2018	Dec 2019	Mock MeerKAT observations of gas in galaxies	Prof. Roy Maartens

2. Co-supervisor's details:

a. **Title and full name:** Prof. Andrew Baker
b. **Name of university:** Rutgers, The State University of New Jersey
c. **Email address:** ajbaker@physics.rutgers.edu
d. **Supervision of postgraduate students:**

Name of student	Nationality	Date started degree	Date completed/ will complete	Title of research project	Co-supervisor
Anthony Young	USA	June 2017	May 2021	Applications of Gravitational Lensing at High Spectral Resolution	N/A
John Wu	USA	June 2013	May 2019	Galaxy Evolution as Traced through Multiple Phases of the Interstellar Medium	N/A
Jesus Rivera	USA	June 2012	May 2019	Detailed Studies of Lensed Dusty Star-Forming Galaxies	N/A
Amitpal Tagore	USA	Feb 2012	Aug 2014	Uncertainties in Pixel-Based Source Reconstruction for Gravitationally Lensed Objects and Applications to Lensed Galaxies	Charles Keeton
Robert Lindner	USA	Jan 2009	Jul 2013	The Growth of Massive Galaxies and Clusters at High Redshift	N/A
Chelsea Sharon	USA	March 2008	May 2013	Molecular Gas in Dusty High-Redshift Galaxies	N/A
Paula Aguirre (Catolica)	Chile	June 2008	Oct 2012	Submillimeter Galaxies: Insights into Their Formation Mechanisms and the Link with Local Massive Ellipticals	Leopoldo Infante
Lisa Wei (Maryland)	USA	Sep 2004	Sep 2010	A Study of Cold Gas and Star Formation in Low-Mass Blue-Sequence E/S0s	Stuart Vogel & Sheila Kannappan
Ross Fadely	USA	Jul 2009	Jul 2010	Multi-Wavelength Applications of Gravitational Lensing	Charles Keeton
Giovanni Cresci (Firenze)	Italy	June 2004	Feb 2006	Galaxy Morphology and Star Formation with Adaptive Optics	Filippo Mannucci, Richard Davies, & Matthew Lehnert

a. **Title and full name:** Prof. Roy Maartens
b. **Name of university:** University of the Western Cape
c. **Email address:** roy.maartens@gmail.com
d. **Supervision of postgraduate students:**

Name of student	Nationality	Date started degree	Date completed/ will complete	Title of research project	Co-supervisor
Geoffrey Okengo	Kenya	2012	2015	Modelling the growth of large-scale structure with interacting fluids	D Bertacca
Didam Duniya	Nigeria	2013	2015	Relativistic effects in SKA and other galaxy surveys	D Bertacca
Sahba Yahya	Sudan	2013	2016	BAO with SKA	C Clarkson
Mahmoud Hashim	Egypt	2013	2016	Imprints of Primordial non-Gaussianity on Large Scale Structure in the Universe	C Clarkson

Plus 3 PhD graduates from Wits and 10 from Portsmouth (UK).

Full research project proposal

Scientific merit

Simulations are used to study the formation processes of galaxies. Connecting the results from simulations directly to observed galaxies is made difficult by the complex astrophysical processes that determine the observable properties of galaxies. One way to avoid these complications is by using observational data to generate quantities that may be linked more directly with the numerical simulations. One such quantity is the galaxy velocity function which describes the number density of galaxies as a function of galaxy circular (i.e., rotational) velocity. It serves as a useful tool for probing connections between large scale physics and galaxy formation when coupled with results from cosmological simulations.

The main aim of this PhD project will be to have a student work with neutral atomic hydrogen (HI) observations from the LADUMA (Looking At the Distant Universe with the MeerKAT Array) large survey project in order to measure the galaxy velocity function out to $z \approx 0.5$. The velocity function will be compared to results from state-of-the-art simulations generated and provided by LADUMA team members. Using HI imaging to directly measure velocity widths of galaxies for samples beyond the local Universe has never been done.

Feasibility

One of the main aims of this project will be to expose the student to real HI data cubes (from LADUMA) and to train them in the basic methods of data reduction and analysis. Once they are familiar with the standard techniques, the student will be tasked with producing various image sets based on different smoothing and weighting schemes in order to test their impact on the use of source-finding software used to recover dynamical parameters of galaxies. This technical component of the project is reasonably self-contained (e.g., it does not require re-calibrating the data), it is not directly on the critical path for producing collaboration-wide data products, and it has a clear connection to the main science goals of the project. Both Dr Elson and Prof. Baker are extensively experienced in the methods of handling and analysing HI data.

The project will focus on the redshift range $z \lesssim 0.5$. While still allowing new regions of the Universe to be probed in HI line emission for the first time, focussing on this redshift range means that the thesis can be completed on the basis of L-band data only.

The measured galaxy velocity widths will be used to construct velocity functions. Focusing on dynamical measurements of galaxies leverages Dr Elson's status as co-lead of the HI dynamics science working group within LADUMA. All supervisors will be able to guide the student in the application of standard methods of constructing velocity functions.

A very important component of the project will involve using simulation results to interpret and conceptualise the results based on the real data. Dr Elson, Prof. Baker, and Prof. Maartens have focused much of their recent research efforts on finding ways to carry out meaningful comparisons between simulated and real data products. Together, they will be able to assist the student in developing, testing, and implementing various simulation-data comparison methods. Having a strong focus on the use of simulations will mean that the student will always have some form of data to work with, even if there are delays in the acquisition of L-band data for LADUMA.

All of the required resources will be provided to the student. As an official LADUMA team member, (s)he will have full access to various subsets of the LADUMA data (at the discretion of the supervisors of this project). At UWC, we have some fairly powerful computers that the student can use to reduce and analyse the LADUMA data. Alternatively, because UWC is an IDIA partner institution, we also have access to IDIA computing resources. At UWC, we have many students working on a variety of SKA-related projects. The student for this project will interact with research groups at both UWC and Rutgers - thereby participating in regular and meaningful interactions with staff members, postdocs and other students.

Links of project to SARAO research priority areas

The proposed project is directly linked to the SKA priority area of "science topics that involve the exploitation of MeerKAT data projected to be available by 2018-2019". The student will literally probe new regions of the Universe the have not been studied in HI line emission.

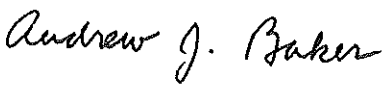
Qualifications, academic abilities, skills/experience required by the student

A student working on this project should have (or be prepared to rapidly achieve) a basic understanding of the fundamentals of radio astronomy and typical HI data products (spectra, cubes, velocity fields, total intensity maps). The student should have a good programming skill set, preferably including a solid background in Python, and ideally including experience in the handling of FITS files and/or CASA measurement sets. Most importantly, the student should be self-motivated and prepared to work diligently, thoroughly, and enthusiastically in collaboration with other members of a large international team.

Primary supervisor: Dr E. Elson

30 August 2018, Cape Town

Co-supervisor: Prof. A. J. Baker



30 August 2018, Cape Town

Co-supervisor: Prof. R. Maartens

30 August 2018, Cape Town