SUBJECT	SKA VLBI Key Science Projects and Operations Workshop, 14-17.10.2019	
DATE / PLACE	14-17/10/2019	Cheshire, United Kingdom
PARTICIPANT	Dr. Jack Radcliffe	
REASON FOR PARTICIPATION	Invited speaker for the conference	
WEBPAGE OF THE EVENT	https://indico.skatelescope.org/event/539/	

1. Agenda

Day 1 – 14/10/2019

Philip Diamond - Introduction to the SKA
Robert Braun - SKA Science objectives and KSP planning
Francisco Colomer - [JUMPING] JIVE in support of SKA and VLBI
Zsolt Paragi - Why VLBI with the SKA? / Workshop Goals
Evan Keane - SKA Observing capabilities and architecture
Cormac Reynolds - VLBI SWG: from requirements to science
Cristina Garcia Miro - SKA-VLBI capabilities
Antonio Chrysostomou - SKA Operational Model
Tao An - SKA Regional Centres and VLBI
Maria Rioja - MultiView Cheatsheet
Richard Dodson - Ultra-precise Astrometry with SKA-VLBI
Christina Garcia Miro - SKA-VLBI Science Cases

Day 2 – 15/10/2019

Leah Morabito - AGN-surveys at low frequencies with the ILT
Jack Radcliffe - Wide-field VLBI surveys in the SKA-era
Preeti Kharb - A look at Double-peaked Emission-Line AGN with VLBI
Pikky Atri - Accreting Galactic black holes with SKA-VLBI
Marcello Giroletti - GW-EM counterparts VLBI follow-up
Miguel Perez-Torres - Supernovae and Nuclear Transients with VLBI
David Williams - Energy Injection in the ULX Holmberg II X-1

Day 3 – 16/10/2019

Dana Simard - Pulsar scintillometry with SKA-Low VLBI
Manisha Caleb - Fast Radio Bursts with VLBI
Franz Kirsten - Mapping the scattering screen of the Vela pulsar
Benito Marcote - A possible connection between an orphan long GRB afterglow and FRBs
Yoon Kyung Choi - Stellar Maser Astrometry with SKA-VLBI
Anita Richards - How evolved stars contribute to the enrichment of the ISM?
Sandra Etoka - Structural changes of stars at dawn and dusk of their evolution
Jan Forbrich - Stellar VLBI Science: young stellar objects, active stars and exoplanets
Huib van Langevelde - Galactic Structure through maser astrometry with VLBI@SKA
Hideyuki Kobayashi - Cradle of Life Science with SKA and VLBI Networks in EA

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Day 4 – 17/10/2019

John McKean - Testing models for dark matter and dark energy with SKA-VLBI
Anna Bonaldi - The SKA Data Challenge
Chris Phillips - The LBA upgrade and role in SKA-VLBI
Mark Sargent - Band 6 for SKA1-Mid
James Chibueze - African VLBI Network (AVN): Catching Galactic Transient Events in the SKA Era
Rhodri Evans - The Africa Millimetre Telescope as part of the AVN
Richard Schilizzi - SKA and VLBI: a historical perspective on current challenges
Leah Morabito - Breakout - AGN Discussion Summary
Hiroshi Imai - Breakout - Stars and Astrometry Discussion Summary
Zsolt Paragi - Breakout - Transients Discussion Summary

2. Notes

2.1 TA project – European Radio Interferometry School 2019 (ERIS2019)

As part of this trip, I lectured at the RadioNET-funded ERIS2019 in Gothenberg, Sweden. This school teaches radio interferometry to ~100 students and persons new to radio interferometry. This includes proposal writing, interferometry theory, data reduction, and data reduction software. These are delivered though lectures and workshops.

As part of this school I delivered the following:

1. Developed and presented a lecture and workshop on self-calibration (link)
2. Developed the workshop on VLBI data reduction (link)
3. Presented a lecture on wide-field VLBI data reduction (link)

2.1 Scientific results from invited presentation

As part of this conference, I gave an invited presentation titled 'Wide-field VLBI in the SKA era'. The following paragraphs summarise the scientific results and motivation presented in this talk.

Active Galactic Nuclei (AGN) are an integral ingredient in galaxy evolution by regulating star formation within the host galaxy. Simulations of galaxy evolution need AGN feedback to match the number of high mass galaxies to observations. Indeed, observational evidence supports this. It was found that the bulk properties of super-massive black holes (SMBH) are correlated with host galaxy properties (e.g. Maggorian+98) indicating co-evolution between host and SMBH. As AGN are so important, a key challenge is to identify the AGN in distant galaxies. Many different multiwavelength methods have been used, but almost all are affected by dust (which can mask the signatures of AGN activity).

However, radio observations are not and provide a dust-independent view into AGN and star-formation activity. Normal radio interferometers detect both of these phenomena therefore identifying AGN is difficult. On the other hand, Very Long Baseline Interferometry (VLBI) can be used to isolate high brightness temperature cores that can only be attributed to AGN activity.

In this talk, I outlined the methods and technologies that have now enabled VLBI to be used as a survey instrument (known as 'wide-field' VLBI). These include the multiple phase centre correlation method (Deller+2011), multi-source self-calibration (Radcliffe+16).

Following this, scientific results from two recent VLBI surveys were presented, namely the COSMOS-VLBA project (Herrera-Ruiz+17) and GOODSN-EVN (Radcliffe+18). In particular, I showed that multi-wavelength AGN classification techniques cannot identify all VLBI-detected AGN. This illustrates that VLBI remains an intergral part in obtaining a complete census of AGN activity across cosmic time. However, a combination of lots of multi-wavelength classifiers do identify all VLBI-detected AGN which verifies the approached used in other deep fields. This result is important for SKA fields as there will not be complete multi-wavelength coverage that is able to identify AGN thus VLBI will be crucial in this regard.

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In addition, I highlighted the other scientific discoveries coming from wide-field VLBI surveys. These include candidate binary super-massive black holes (Deane+14, Herrera-Ruiz+17, Radcliffe+in prep.), gravitational lenses (Spingola+18,19), and radio supernovae (Radcliffe+19).

Finally, I concluded with the current update to MeerKAT-VLBI and the tests taken in order to make it operational. This included the presentation of the first fringes to MeerKAT from the European VLBI Network (EVN).

Link to presentation: 'Wide-field VLBI surveys in the SKA-era'

RadioNet infrastructures used in scientific results: European VLBI Network (project codes EG078, ER047, N18L1), e-MERLIN

3. IDEAS / Conclusions

The following section outlines the various outcomes/ideas generated at the meeting that I participated in.

Science-use case refinement

A key aspect of this conference was the refining of science-use cases for the Square Kilometre Array (SKA) being included within the worldwide Very Long Baseline Interferometry (VLBI) arrays. In 2018, initial science-use cases were developed and one of the purposes of this workshop was the develop and generate new cases. Over the course of the conference, there were breakout sessions that were used to generate these ideas. Before the conference, there were 22 science cases but this now 35 in total. The science cases are important in securing the necessary investment by the SKA in making it VLBI capable.

Establishment of the SKA-VLBI Capabilities working group

The conference included breakout sessions where the various science cases for SKA-VLBI were fleshed out. From these discussions, it was shown that there was a distinct need to understand the operational modes and capabilities of a VLBI array with SKA included. In light of this, the SKA-VLBI capabilities working group was established (Chair: J. Radcliffe). This group aims to answer the following key questions that will influence future SKA-operations:

1. How will the inclusion of the SKA affect the performance of the various VLBI arrays around the world.
2. What sub-arraying strategies (phasing SKA antennas together) will be possible given the current constraints with the SKA correlator? How will these be maximised for different surveys e.g. wide-field surveys, single objects
3. What cost would the removal of SKA telescopes used as part of a VLBI array have on the imaging fidelity of the SKA?

This group will be a key player in determining the SKA-VLBI operational modes in the future. In particular, the SKA stated that they require 'standard' observing sub-arraying templates for VLBI operations. These templates will be determined by this new working group and will be optimised for a range of science cases. For example, if we are to survey a large area of the sky with VLBI, we would want to combine individual telescopes that are close together (at the field-of-view is inversely proportional to the distance between the telescopes in a sub-array). The way in which you determine these templates with the large amount of telescopes is non-trivial.

Establishment of 'VLBI commensality champions'

Over the course of the conference, it was suggested that the VLBI science working group (SWG) should nominate commensality representatives who would represent the interest of VLBI in other working groups. This makes sense simply because there is a large overlap between science cases set out in other working groups and VLBI. For example, the active galactic nuclei (AGN) and star-

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formation studies proposed by the Continuum SWG benefit greatly from VLBI observations that can isolate contributions from AGN in their objects.

Development of the 'International VLBI alliance'

A key concept that has been proposed is called the 'international VLBI alliance' where the major VLBI observatories, e.g. LBA (Australia), VLBA (USA), EVN (Europe/Asia), EAVN (Asia). Such an alliance was proposed in this meeting as major players from each observatory was present. The objective of such an alliance is to share knowledge, techniques and expertise in order to ensure that VLBI continues to make great discoveries in the future.

Conclusions

To conclude, the SKA-VLBI operations workshop was a great success and brought together the leading experts across the world in order to discuss the past, present and future of VLBI. In particular, significant progress was made on the next steps and the role of VLBI in the SKA-era. This is of vital importance to keep the various observatories producing great science. My role across this trip was extremely important and I have now established the SKA-VLBI capabilities working group that will be influential in SKA policy and observing strategies.

Author
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