Report from event supported by RadioNet

Title	**SKA-VLBI Key Science Projects and Operations workshop**
Date:	14-17 October 2019
Location:	Jodrell Bank, UK
Meeting webpage:	*https://indico.skatelescope.org/event/539/overview*
Host Institute:	SKA Headquarters
RadioNet beneficiary / no:	*JIV-ERIV / 05*

Report:

Scientific summary

The Square Kilometre Array (SKA) will deploy its first phase telescopes in the mid-2020s. SKA1-low (50-350 MHz) and SKA1-mid (0.35-15.3[24.0] GHz) will have maximum baseline lengths of about 65km and 150 km, respectively. Some of the highest priority science objectives defined by the SKA Organisation - together with the science working groups - however require an angular resolution that can only be reached by

current very long baseline interferometry (VLBI) networks, or the full SKA with baselines extending to thousands of km. To exploit the full potentials of the first phase SKA components for very high resolution applications, it has been proposed to coherently phase-up the core of SKA1-LOW and SKA1-MID, and make these powerful telescopes available for global VLBI observations.

In the past 50+ years the VLBI technique has provided the highest angular resolution imaging application in observing astronomy. It provided means to measure apparent superluminal motion in highly relativistic jets from active galactic nuclei (AGN) some 40 years ago, while today we can directly observe the impact of these jets to the neutral and molecular interstellar medium as they drive powerful large-scale outflows - an important form of AGN feedback that shapes galaxies. The superior relative astrometric capabilities allowed us to measure accurate distances and proper motions well before the Gaia era, which helped us to better understand stellar birth and stellar evolution, as well as the structure of the Milky Way. Absolute astrometry with VLBI allows us to measure Earth Orientation Parameters and UT1, and may be used for cosmological studies. In the field of transient science, VLBI has provided the first clue that Nova ejecta can be highly asymmetric, it made possible to resolve (mildly)-relativistic ejecta from Tidal Disruption Events, and provided the tightest constraints on the position of the first ever localised fast radio burst FRB121102.

The aim of the workshop was to introduce the VLBI capabilities and observing modes of the SKA to the community, and present the latest results in the SKA high priority science areas where VLBI will make an impact. We discussed ideas and possible strategies for major SKA-VLBI Key Science observing programmes, and the impact of global VLBI observations for astronomical research in the future in general. In addition, we acquired input regarding the SKA-VLBI requirements for the future SKA Regional Centres.

The first day of the workshop was devoted to the introduction of different aspects of the SKA Observatory, focusing on the VLBI capability and the portfolio of SKA-VLBI science cases recently compiled with the help of the SKA VLBI Science Working Group and coordinated and realized by the JUMPING JIVE project. The latest developments in the SKA project were presented by Phillip Diamond and Robert Braun, both from the SKA Organisation.

The rest of the workshop was organised into sessions focused on different science topics: active galactic nuclei, transient events, pulsars and fast radio bursts, stellar astrometry and prospects for SKA-VLBI including African telescopes. The main topics were selected in the areas of SKA high priority science objectives. The talks highlighted the need for very high angular resolution that can only be achieved by including the phase 1 SKA telescopes in VLBI arrays. It was agreed that simulations will be an important tool to demonstrate how to achieve the ambitious science goals. Anna Bonaldi from the SKA Science Team presented options about how to include VLBI in the SKA data challenges. The discussion about how to realize SKA-VLBI Key Science Projects continued in four working groups based on the workshop's main science topics. The outcomes of the break-out sessions were presented on the last day of the workshop by the chairs. Some very interesting ideas emerged during these discussions. The possibility of achieving record relative astrometric precisions down to 1 microarcsecond was one of these. It was also argued that individual outrigger SKA antennas should be made available for VLBI

together with the phased-up core, which would naturally provide the short spacings needed in support of VLBI imaging and calibration. The idea of piggy-backing some of the SKA1 surveys on SKA-VLBI observations (rather than the other way around) received much attention. And, of course, increasing the number of tied-array VLBI beams available in the SKA1 telescopes came up often.

The wrap-up of the workshop was presented by Richard Schilizzi, who summarised the various lessons learned from the European VLBI Network and other global initiatives and provided very good suggestions for harmonising the VLBI world with the SKA. The workshop was a great success and a number of participants signed up for the SKA VLBI Science Working Group to contribute to the SKA-VLBI effort.

RadioNet relevance

A number of the participants were from EVN observatories, or were otherwise EVN users. The EVN is an SKA pathfinder, and our community will provide the basis for future users of SKA-VLBI. The development of SKA-VLBI is supported by the European Union's Horizon 2020 research and innovation programme JUMPING JIVE [grant agreement No 730884] and the SKA VLBI Working Group. We received further support from the SKA Organization, and two invited speakers have been approved for RadioNet support [grant agreement No 730562].

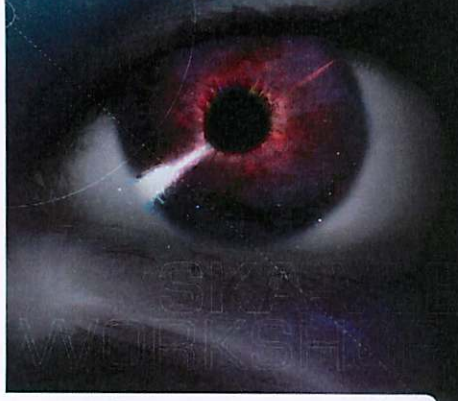
Impact

The main impact of the event was the full recognition of the efforts of our community and especially by JJ WP10 and the SKA Organisation. The D10.1 deliverable of our project was formally recognized as one of the baseline design SKA technical documents. In his concluding remarks, the SKA General Director Director-General, Phil Diamond, gave his word at the workshop to realise VLBI with phase I of the SKA Observatory telescopes. Following the workshop, the SKA Scientific Director, Robert Braun, initiated further discussions about the possibility of having a small number of additional antennas in Australia and in South Africa, that would help the realization of SKA-VLBI (especially for SKA1-LOW as there are only very few low-frequency antennas are available to form a VLBI array). A number of people signed up to the SKA VLBI Science Working Group as well. In summary, we successfully mobilised our community, and also obtained full support from SKAO to achieve our goals, to realize SKA-VLBI.

Agenda of the event

SKA-VLBI WORKSHOP

THE WORLD'S EYE ON THE SKY



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MONDAY

10:25	**Session I. SKA & VLBI**
10:25	Welcome by the Organizers
10:30	Phil Diamond: Introduction to the SKA
11:00	Robert Braun: SKA Science objectives and KSP planning
11:30	Francisco Colomer: [JUMPING] JIVE in support of SKA and VLBI
11:45	Zsolt Paragi: Why VLBI with the SKA? / Workshop goals
12:00	Lunch
13:30	**Session II. Implementing SKA-VLBI**
13:30	Evan Keane: SKA Observing capabilities and architecture
14:00	Cormac Reynolds: VLBI SWG: from requirements to science
14:15	Cristina Garcia-Miro: SKA-VLBI capabilities
14:45	Antonio Chrysostomou: SKA Operational model
15:15	Tao An: SKA Regional Centres and VLBI
15:30	Coffee break
16:00	**Session III. Science Use Cases**
16:00	Richard Dodson: Ultra-precise astrometry with SKA-VLBI
16:30	Cristina Garcia-Miro/Zsolt Paragi: SKA-VLBI Use Cases & Matching to SKA resources
16:45	Forming KSP groups; discussion continue over wine & cheese
17:00	Wine and Cheese Party
18:30	End of day 1

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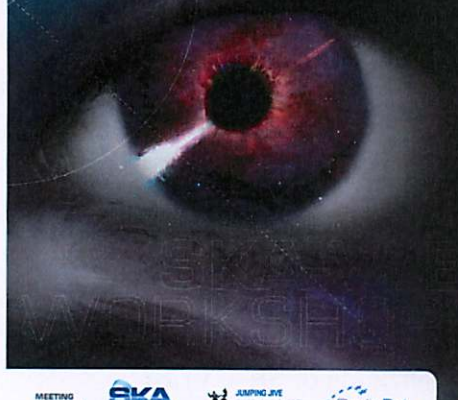

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TUESDAY

9:00	**Session III. Active Galactic Nuclei**
9:00	Leah Morabito: AGN-surveys at low frequencies with the ILT
9:30	Jack Radcliffe: Wide-field VLBI surveys in the SKA-era
10:00	Preeti Kharb: A Look at Double-peaked Emission-Line AGN with VLBI
10:30	Coffee break
11:00	**Session VI. Transients**
11:00	Pikky Atri: Accreting Galactic black holes with SKA-VLBI
11:30	Marcello Giroletti: GW-EM counterparts VLBI follow-up
12:00	Miguel Perez-Torres: Supernovae and Nuclear Transients with VLBI
12:30	David Williams: Energy injection in the ULX Holmberg II X-1
12:45	Workshop photo
13:00	Lunch
14:00	Parallel sessions for KSP groups
15:30	Coffee break
16:00	Parallel sessions for KSP groups
17:30	End day 2

Participants

The SKA-VLBI Key Science Projects and Operations workshop gathered together 65

scientists from 18 different countries. These included both experienced researchers who have been developing very long baseline interferometry (VLBI) and/or the Square Kilometer Array (SKA) for many decades, and a great number of young people, some also from countries that have no VLBI facilities. The SOC had 40%-60% ratio of woman and man. The workshop adopted the SKAO Code of Conduct. The workshop was fully open, the gender distribution of the participants reflected that of the community interested in SKA-VLBI (20 women out of 65 participants).

Takuya Akahori, NAOJ, Japan
Tao An, ShAO, China
Sonia Anton, CIDMA&Dep Physics - Univ Aveiro, Portugal
Megan Argo, University of Central Lancashire, UK
Bernard Duah Asabere, ASTRON, Netherlands
Pikky Atri, ICRAR-Curtin University , Australia
Rob Beswick, University of Manchester, UK
Ian Brown, JBCA, UK
Manisha Caleb, JBCA, UK
Patrick Charlot, Laboratoire d'Astrophysique de Bordeaux, France
Hongying Chen, JBCA, UK
James Chibueze, North West University, SA
Yoon Kyung Choi, MPIfR, Germany
Antonio Chrysostomou, SKA, UK
Francisco Colomer, JIVE, NL
Jimmy Cullen, JBCA, UK
Joseph Diamond, SKA, UK
Richard Dodson, ICRAR/UWA, UK
Sandra Etoka, JBCA, UK
Rhodri Evans, University of Namibia, SA
Jan Forbrich, University of Hertfordshire, UK
Cristina Garcia Miro, SKA, UK
Michael Garrett, University of Manchester & Leiden, UK
Marcello Giroletti, INAF Istituto di Radioastronomia, Italy
Nusrin Habeeb, United Arab Emirates University, UAE
Jeffrey Hodgson, Korea Astronomy and Space Science Institute, South Korea
Hiroshi Imai, Kagoshima University, Japan
Sandy Jones, Geoscience Australia, Australia
Matthias Kadler, Uni Wuerzburg, Germany
Hilary Kay, University of Manchester, UK
Preeti Kharb, National Centre for Radio Astrophysics, India
Franz Kirsten, Chalmers University of Technology, Sweden
Hideyuki Kobayashi, National Astronomical Observatory of Japan, Japan
Robert Laing, SKA, UK
Jingjing Li, Purple Mountain Observatory, China
Michael Lindqvist, Onsala Space Observatory, Sweden
Benito Marcote, JIVE, Netherlands
John McKean, ASTRON / Kapteyn Astronomical Institute, Netherlands

Leah Morabito, Durham University, UK
Tom Muxlow, JBCA, UK
Dhanya Nair, JIVE, Netherlands
Ann Njeri, JBCA, UK
Zsolt Paragi, JIVE Netherlands
Miguel Perez-Torres, IAA, Spain
Chris Phillips, CSIRO, Australia
Richard Porcas, MPIfR, Germany
Nkululeko Qwabe, SARAO, South Africa
Jack Radcliffe, University of Pretoria / SARAO
Cormac Reynolds, CSIRO, Australia
Anita Richards, JBCA, University of Manchester, UK
Maria Rioja, ICRAR-UWA;CSIRO;OAN, UK
Mark Sargent, U. of Sussex, Astronomy Centre, UK
Richard Schilizzi, The University of Manchester, UK
Dana Simard, University of Toronto, Canada
Huib van Langevelde, JIVE, Netherlands
Tiziana Venturi, NAF, Istituto di Radioastronomia, Italy
Peter Wilkinson, University of Manchester, UK
David Williams, University of Oxford, UK
Nick Wrigley, JBCA, UK
Ye Xu, Purple Mountain Observatory, China

The group photo made during the SKA-VLBI Key Science Projects and Operations workshop:

Credit: SKAO/JIVE

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Bernard Duah Asabere, bd.asabere@gmail.com
Pikky Atri, pikky.atri@postgrad.curtin.edu.au
Sonia Anton, santon@ua.pt
James Chibueze, james.chibueze@gmail.com
Nkululeko Qwabe, nqwabe@ska.ac.za
David Williams, david.williams@physics.ox.ac.uk
Dana Simard, simard@astro.utoronto.ca
Ann Njeri, ann.ngendo@postgrad.manchester.ac.uk
Preeti Kharb, preeti.kharb@gmail.com
Rhodri Evans, revans@unam.na
Antonio Chrysostomou, A.Chrysostomou@skatelescope.org

RadioNet financial contribution

These two invited speakers were supposed to receive financial support from RadioNet:

Yoon Kyung Choi, MPIfR, Germany
Miguel Perez-Torres, IAA, Spain

Publications

The project leading to this publication has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730562 [RadioNet]

Confirmation

Following the Regulation (EU) 2016/679 - General Data Protection Regulation-, we ask you to confirm that RadioNet is allowed to publish this report, incl. participants lists, statistic´s details, pictures, etc..

Yes