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ASKAP Science Update

CSIRO Astronomy and Space Science May 2010

The ASKAP Science Update is a regular series dedicated to conveying the latest news about the Australian SKA Pathfinder (ASKAP) project to the international science community. It is also available online at www.atnf.csiro.au/projects/askap.

ASKAP Simulations Underway

Creation of realistic simulated skies, imaging of the simulations using ASKAP's configuration and software tools, and finding sources in the output images and cubes are important aspects of planning for the science that will be conducted with ASKAP.

To achieve these goals CSIRO's ASKAP team has been working closely with members of the ten Survey Science Projects that will use ASKAP in its first five years of operation.

"Source finding is critical for several Survey Science Projects, particularly those projects that plan to observe a substantial fraction of the visible sky," says ASKAP Project Scientist Simon Johnston.

"The Widefield ASKAP L-Band Legacy All-Sky Blind Survey (WALLABY) project, for example, aims to find up to 500,000 galaxies in HI, and the Evolutionary Map of the Universe (EMU) project expects to see more than 10 million sources."

An automated source finder that maximises completeness while minimising the number of false detections is key. For this reason, two sets of simulations have been provided to the project teams: one of the continuum sky and one of the extragalactic HI sky.

The source catalogue for the simulations came from the SKADS S3-SEX (continuum) and SKADS S3-SAX (HI) work carried out at Oxford University in the UK, while the simulations were made possible by the loan of a pre-production computer by Intel Australia.

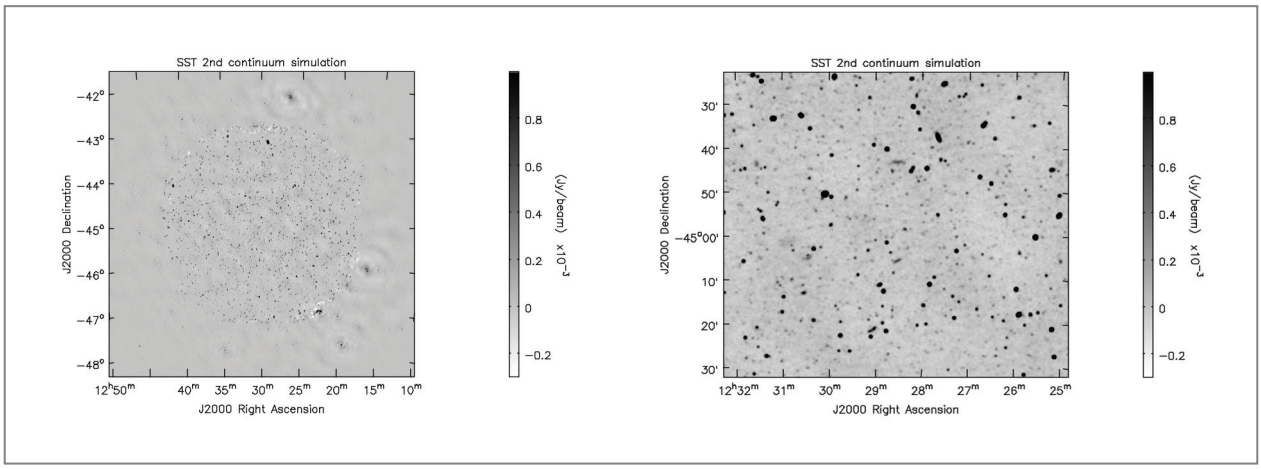
The telescope simulation used the 2 km core of the ASKAP configuration (which includes 30 of ASKAP's 36 antennas) along with 32 idealised beams spaced in a rectangular grid.

For the continuum simulation the total bandwidth was 300 MHz divided into 120 channels and, after an eight-hour integration, the image noise was 11 uJy/beam. For the HI simulation, 1024 channels covering almost 100 MHz were used. Two cubes were made centred at -45 and -3 declination to explore the effects of the changing point spread function.

The output images and cubes have been made available to the members of the Survey Science Projects for testing their source-finding algorithms.

The next simulations will be ready in coming weeks. These will incorporate full polarisation information and will contain transient sources so that the Polarization Sky Survey of the Universe's Magnetism (POSSUM) and ASKAP Survey for Variable and Fast Transients (VAST) project teams can start to hone their source-finding algorithms. CSIRO's ASKAP team will then look to include galactic continuum and spectral line information into the simulations.

"Plenty of work still lies ahead for the ASKAP team and the project teams over the coming year, but these initial simulations and images are a great start," says Simon.



> Two images showing a simulation of an ASKAP observation of the broadband emission from the sky, with the centre at 1.37 GHz (the right image is a 'zoomed in' version of part of the left image). This simulation includes a number of effects including thermal noise from the receivers and wide field-of-view imaging corrections. Credit: Tim Cornwell, CSIRO.

"WALLABY will provide the largest, most homogeneous HI sample of galaxies, complemented by similarly uniform multi-wavelength data, yet made."

ASKAP Survey Science Projects

In this edition of *ASKAP Science Update* we take a detailed look at two of the projects that will make use of ASKAP during its first five years of operation.

WALLABY Success a Team Effort

"I'm excited by the opportunity to make discoveries with ASKAP," says CSIRO's Bärbel Koribalski, one of the Widefield ASKAP L-Band Legacy All-Sky Blind Survey (WALLABY) Principal Investigators.

"These might be new galaxies, large gas disks around known galaxies, or gas clouds such as tidal tails and plumes."

Bärbel, co-Principal Investigator Lister Staveley-Smith (International Centre for Radio Astronomy Research) and a team of international collaborators will build on the 60-year legacy of other research that has used the 21-cm line of neutral hydrogen, or HI line, to investigate the evolution and dynamics of galaxies.

WALLABY will conduct an extragalactic neutral hydrogen survey over 75% of the entire sky. Along with the Evolutionary Map of the Universe (EMU) project (see *ASKAP Science Update February 2010*), WALLABY is one of the largest surveys that will be undertaken by ASKAP in its first five years of operation with a request for one year of observing time.

The project aims to examine the HI properties and large-scale distribution of up to 500,000 galaxies to a redshift of 0.26, in order to study:

- Galaxy formation and the missing satellite problem in the Local Group;
- Evolution and star formation in galaxies;
- Mergers and interactions in galaxies;
- Physical processes governing the distribution and evolution of cool gas at low redshift;
- Cosmological parameters relating to gas-rich galaxies;
- The nature of the cosmic web.

By comparison, only about 22,000 galaxies with HI emission are currently known.

"WALLABY will provide the largest, most homogeneous HI sample of galaxies, complemented by similarly uniform multi-wavelength data, yet made," says Bärbel.

> The international WALLABY team, led by Lister Staveley-Smith and Bärbel Koribalski, will use ASKAP to conduct an extragalactic neutral hydrogen survey over 75% of the entire sky. Credit: Gabby Russell, CSIRO.

And the sensitive HI observations to be made by WALLABY will benefit from the exceptional interference-free environment at the Murchison Radio-astronomy Observatory.

"The quality of data obtained with ASKAP should be fantastic," says Bärbel.

The results generated will also provide an important insight into what could be achieved with the Square Kilometre Array, which will conduct more sensitive HI surveys for galaxies at higher redshifts than WALLABY.

The two Principal Investigators certainly won't be working alone to meet WALLABY's science goals – the WALLABY team consists of nearly 100 people from around the world.

"While many team members are based in Australia, there are key groups at many institutions spread over different continents," says Lister.

"Our collaboration with team members in The Netherlands is particularly important with respect to achieving a true all-sky survey, which can best be delivered by ASKAP and the new fully funded APERTIF upgrade to the Westerbork Synthesis Radio Telescope."

"Similarly, we are collaborating closely with team members in South Africa who are keen to carry out deep HI observations of galaxies with MeerKAT."

"All the team members are contributing to the breadth of science that we will be doing from hydro-dynamical simulations, exploring optimal source-finding algorithms, the study of cross-correlation functions and large-scale structure as well as complementary multi-wavelength observations of each detected galaxy," continues Lister.

Science Goals Align for POSSUM

How are large-scale cosmic magnetic fields generated and maintained? That's the central question that the team behind the Polarization Sky Survey of the Universe's Magnetism (POSSUM) project is looking to answer.

The polarisation angle of light emitted by cosmic objects can be altered as the light passes through a region of magnetised gas, an effect known as 'Faraday rotation'.

Led by Bryan Gaensler (University of Sydney, Australia), Russ Taylor (University of Calgary, Canada) and Tom Landecker (Dominion Radio Astrophysical Observatory, Canada), POSSUM will use ASKAP to explore cosmic magnetism by measuring the polarisation of radio signals reaching the telescope.

From Earth the dominant 'foreground' magnetised object is the Milky Way, which fills the entire sky. POSSUM will probe the magnetic field of the Milky Way with over a million lines of sight to polarised background sources. Beyond the Milky Way, ASKAP will allow the POSSUM team to explore the magnetic properties of the extragalactic Universe.

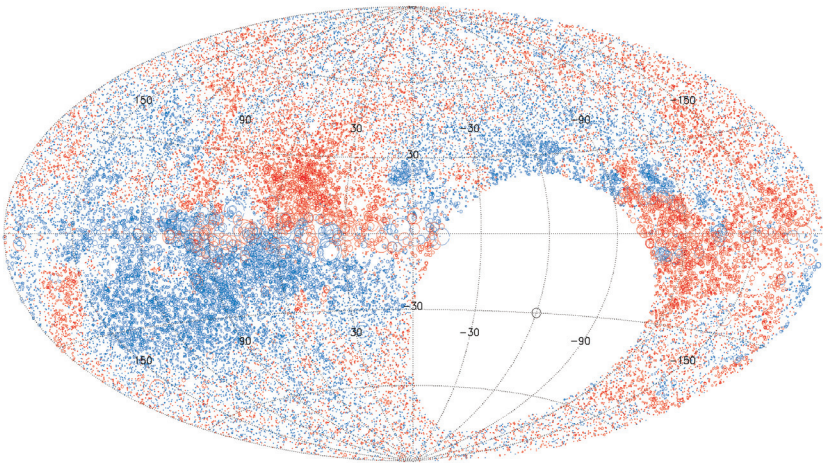
"POSSUM will yield a densely packed grid of millions of Faraday rotation measures over a substantial fraction of the sky," says Bryan Gaensler, whose main research interest in POSSUM is the use of rotation measures as probes of the Galactic and intergalactic fields, and to study the intrinsic rotation measure properties of active galactic nuclei.

"It will revolutionise our understanding of magnetic fields in the Milky Way, other galaxies and clusters, and in the intergalactic medium."

Russ Taylor is also interested in learning more about the intrinsic properties of active galactic nuclei and galaxies as probes of the evolution of magnetic fields with cosmic history.

"ASKAP will provide a huge step beyond the capability of existing telescopes for this work through its wide field-of-view and its great sensitivity," says Russ.

"We will be able to detect polarised radio emission to most radio-loud active galactic nuclei and radio galaxies in the Universe, as well as from large numbers of galaxy disks out to intermediate redshifts."

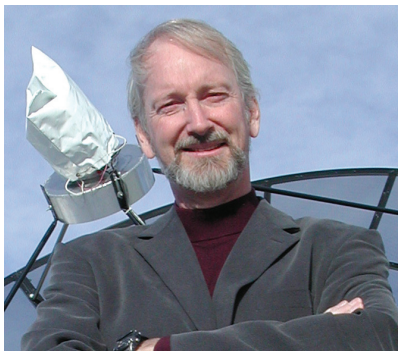


> A NRAO Very Large Array Sky Survey image of the sky in polarisation. Credit: Russ Taylor.

"We will also make the first significant steps before the SKA to explore the magnetic properties of galaxies, the role of magnetism in star formation, and the evolution of fields with cosmic time."

POSSUM will allow Tom Landecker to study the polarised emission that is generated by the Milky Way itself in order to shed light on the role of magnetic fields in processes that take place in the interstellar medium.

"Stars in the Milky Way form from interstellar gas enriched by the traces of older generations of stars. New stars impact their surroundings through stellar winds and supernova explosions. We know that magnetic fields play important roles in this Milky Way 'ecosystem' at all stages of these processes, but we know very little about the details. POSSUM will advance us in this quest," says Tom.



> The POSSUM team is made up of Bryan Gaensler, Russ Taylor and Tom Landecker (above left to right), and 52 co-investigators spread across 14 countries. Several postdoctoral fellows and a new PhD student have also recently joined the team. Credits: Mark Sims/Anglo-Australian Observatory, University of Calgary and Dominion Radio Astrophysical Observatory.

Awards Boost SKA Effort

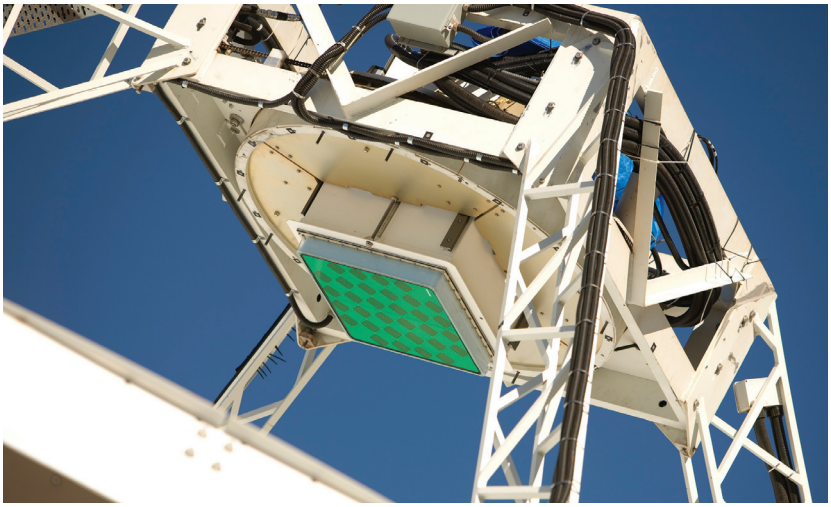
CSIRO has been awarded three of the Australian Research Council's new Super Science Fellowships, worth a total of A$835,000 over three years. The Fellowships are designed to give early-career researchers the opportunity to work in areas of national significance.

One of the Fellows will work to refine a device CSIRO has pioneered for ASKAP – an innovative phased array feed that sits at the focal centre of each of ASKAP's 36 dishes.

The other two Fellowships are for science with ASKAP: one is for WALLABY and the other for EMU-related research.

"These Fellowships will help ensure Australia's readiness for the SKA, boosting essential research and development at the interface between engineering and astronomy within CSIRO and in University groups in Australia and around the world," says Lewis Ball, Acting Chief of CSIRO Astronomy and Space Science.

In total, 21 of the 100 awards (valued at almost A$5 million over the next five years) are for developing SKA pathfinder instruments and SKA-related research in Australia.



> A prototype of ASKAP's innovative phased array feed receiver, which will be refined by CSIRO for possible use in the SKA. Credit: David McClenaghan, CSIRO.

Forthcoming Meetings

Members of the ASKAP team will be attending a number of upcoming scientific meetings:

- Cosmic Magnetism: From Stellar to Intergalactic Scales
  Kiama, Australia
  7–11 June 2010
- A New Golden Age for Radio Astronomy
  Assen, The Netherlands
  10–14 June 2010
- International SKA Forum 2010
  Assen, The Netherlands
  15 June 2010
- Astronomical Society of Australia Annual Science Meeting 2010
  Hobart, Australia
  5–8 July 2010

If you would like to find out more or have questions about ASKAP please don't hesitate to find us, we look forward to meeting you.

For further information:

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