PROCEEDINGS OF SCIENCE

The Australian Square Kilometre Array Pathfinder (ASKAP) an SKA pre-cursor

Ilana Feain
CSIRO – ATNF
PO Box 76, Epping NSW 1710, Australia
E-mail: Ilana.Feain@csiro.au

Simon Johnston
CSIRO – ATNF
PO Box 76, Epping NSW 1710, Australia
E-mail: Simon.Johnston@csiro.au

Robert Braun[1]
CSIRO – ATNF
PO Box 76, Epping NSW 1710, Australia
E-mail: Robert.Braun@csiro.au

PoS(PRA2009)002

The future of cm and m-wave astronomy lies with the Square Kilometre Array (SKA), a telescope under development by a consortium of 17 countries that will be 50 times more sensitive than any existing radio facility. Most of the key science for the SKA will be addressed through large-area imaging of the Universe at frequencies from a few hundred MHz to a few GHz. The Australian SKA Pathfinder (ASKAP) is a technology demonstrator aimed in the mid-frequency range, and achieves instantaneous wide-area imaging through the development and deployment of phased-array feed systems on parabolic reflectors. The large field-of-view makes ASKAP an unprecedented synoptic telescope that will make substantial advances in SKA key science. ASKAP will be located at the Murchison Radio Observatory in inland Western Australia, one of the most radio-quiet locations on the Earth and one of two sites selected by the international community as a potential location for the SKA. In this paper, we outline the ASKAP project and summarise its headline science goals as defined by the community at large.

Panoramic Radio Astronomy: Wide-field 1-2 GHz research on galaxy evolution - PRA2009
Groningen, the Netherlands
June 02-05, 2009

[1] Speaker

© Copyright owned by the author(s) under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike Licence. http://pos.sissa.it

1.Introduction

The Australian SKA Pathfinder (ASKAP) is a next generation radio telescope on the strategic pathway towards the staged development of the Square Kilometre Array (SKA). In this short conference paper an overview of ASKAP is given and a brief description of some indicative science programs. An expanded write-up of the ASKAP science case can be found in the two refereed papers (Johnston et al. 2007[1] and Johnston et al. 2008[2]). Details and updates for the ASKAP project more generally can be found on the web at http://www.atnf.csiro.au/projects/askap. ASKAP has four main goals:

- To demonstrate and prototype technologies for the mid-frequency SKA, including field-of-view enhancement by focal-plane phased-arrays on new-technology 12-m class parabolic reflectors;
- To carry out world-class, ground breaking observations directly relevant to the SKA Key Science Projects;
- To establish a site for radio astronomy in Western Australia where observations can be carried out free from the harmful effects of radio interference;
- To establish a user community for the SKA.

2. ASKAP System Parameters

Table 1 gives the ASKAP system parameters. The first column gives the relevant parameter with the second column listing the value of that parameter.

Table 1. System parameters for ASKAP. Note that the field of view is frequency independent.

Parameter	Value
Number of Dishes	36
Dish Diameter (m)	12
Total collecting area (m^2)	4072
Aperture Efficiency	0.8
System Temperature (K)	50
Field-of-view (deg^2)	30
Frequency range (MHz)	700 – 1800
Instantaneous Bandwidth (MHz)	300
Maximum number of channels	16384
Configuration maximum baseline (m)	6000

2.1 Survey Speeds

There are two important metrics for telescopes like ASKAP. The first is the survey speed; the amount of sky which can be surveyed in a given time to a given sensitivity. The second is

PoS(PRA2009)002

the instantaneous sensitivity. The first metric can be expressed as a proportionality $\propto A^2 \times T^{-2} \times F$, where A is the total (effective) collecting area (m^2), T the system temperature (K) and F the field of view (sq deg). Instantaneous sensitivity is proportional to $A \times T^{-1}$. The survey speed for ASKAP is 1.3×10^5 m^4 K^{-2} deg^2 and the sensitivity is 65 m^2 K^{-1}. This is a few percent of that expected for the final SKA design.

In Table 2 the sensitivities and survey speeds for different angular resolutions are given. The first entry gives a continuum survey speed where the entire 300 MHz of bandwidth is exploited and a desired 1-σ sensitivity of 100 μJy is required. The second entry lists the continuum sensitivity for a one hour observation. The third entry gives a spectral line survey speed with a spectral resolution of 100kHz and a desired sensitivity of 5 mJy, with the fourth listing the line sensitivity for a one hour observation. The fifth line gives the surface brightness survey speed for a 1-σ limit of 1 K over 5 kHz channel and the final entry the surface brightness sensitivity reached in a one hour observation.

Table 2. Sensitivity and survey speeds for ASKAP for different angular resolutions, assuming a 50 K system temperature.

Parameter	10”	18”	30”	90”	180”	unit
Continuum survey speed (300 MHz, 100 μJy)	220	361	267	54	17	deg^2/hr
Continuum sensitivity (300 MHz, 1 hr)	37	29	34	74	132	μJy/beam
Line survey speed (100 kHz, 5 mJy)	184	301	223	45	14	deg^2/hr
Line sensitivity (100 kHz, 1hr)	2.1	1.6	1.9	4.1	7.3	mJy/beam
Surface brightness survey speed (5 kHz, 1 K)	–	–	1.1	18	94	deg^2/hr
Surface brightness sensitivity (5 kHz, 1hr)	–	–	5.2	1.3	0.56	K

2.2 Array Configuration

A number of science projects (pulsar surveys, Galactic HI, low surface brightness mapping) require a highly compact array configuration in order to increase the surface brightness survey speed. On the other hand science such as continuum and transients require long baselines both to overcome the effects of confusion and to obtain accurate positions for identification at other wavelengths. In the middle is the extragalactic HI survey which needs moderate resolution to avoid over-resolving the sources. With a total of 36 dishes, it is difficult to achieve all these requirements simultaneously. The initial ASKAP array configuration (Gupta et al. 2008)[3] has 28 antennas arranged within a circle of diameter ~2km, with a further 8 antennas placed up to ~3km from the configuration centre yielding a maximum baseline of ~6km. This configuration takes into account a mask of the Murchison Radio Observatory site. This configuration is optimized to produce excellent sensitivity and a good point spread function at an angular resolution of 30” at 1.4 GHz. The configuration also provides high angular speed at an angular resolution of 10” and good surface brightness accuracy. This configuration is expected to return excellent science outcomes for ASKAP for at least the first five years of science operations. Future upgrade paths consisting of antenna reconfiguration or more antennas generally will be contingent on future resources and will be driven by community desire.

PoS(PRA2009)002

2.3 Location of ASKAP

The central core of ASKAP will be located at the Murchison Radio Observatory in inland Western Australia, one of the most radio-quiet locations on the Earth and one of only two sites short-listed by the international community as a potential location for the SKA; the second site is located in Southern Africa. The approximate geographical coordinates of the site are longitude 116.5 east and latitude 26.7 south. The choice of site ensures that ASKAP will be largely free of the harmful effects of radio interference currently plaguing the present generation of telescopes, especially at frequencies around 1 GHz and below.

2.4 Timeline

In early 2008, the ASKAP test bed antenna was installed at the site of the 64-m Parkes radio telescope to allow testing of the focal plane array and beam-forming systems. In late 2008, the antenna contract for the 36 ASKAP dishes was signed. The first 6 antennas of ASKAP will be on-site and operational in Western Australia by late 2010 and constitute the Boolardy Engineering Test Array (BETA). Over the subsequent two years the remainder of the antennas will be deployed, with commissioning of the final system expected to take place in late 2012.

3. Science with ASKAP

Following international science meetings held in Australia in April 2005 and March 2007, seven main science themes have been identified for ASKAP. These are extragalactic HI science, continuum science, polarization science, Galactic and Magellanic science, VLBI science, pulsar science and the radio transient sky. In this paper, we can do no more than list bullet points for each science section. An extended version of the science case has already been published (Johnston et al. 2007)[1], with larger, and more complete, version of the science case for ASKAP published in Experimental Astronomy (Johnston et al. 2008)[2].

The technological innovation of ASKAP and the unique radio quiet location in Western Australia will enable a powerful synoptic survey instrument that will make substantial advances in SKA technologies and on three of the SKA key science projects: the origin and evolution of cosmic magnetism, the evolution of galaxies and large scale structure, and strong field tests of gravity. The headline science goals for ASKAP are:

- The detection of a million galaxies in atomic hydrogen emission across 80% of the sky out to a red-shift of 0.2 to understand galaxy formation and gas evolution in the nearby Universe
- The detection of synchrotron radiation from 60 million galaxies to determine the evolution, formation and population of galaxies across cosmic time and enabling key cosmological tests.

PoS(PRA2009)002

- The detection of polarized radiation from over 500,000 galaxies, allowing a grid of rotation measures at 10 arcmin spacing to explore the evolution of magnetic fields in galaxies over cosmic time.
- The understanding of the evolution of the interstellar medium of our own Galaxy and the processes that drive its chemical and physical evolution.
- The characterization of the radio transient sky through detection and monitoring of transient sources such as gamma ray bursts, radio supernovae and intra-day variables.
- The discovery and timing of up to 1000 new radio pulsars to find exotic objects and to pursue the direct detection of gravitational waves.
- The high-resolution imaging of intense, energetic phenomena through improvements in the Australian and global Very Long Baseline networks.

PoS(PRA2009)002

3.1 Survey Science Projects

Expressions of Interest (EoI) for survey science projects closed on December 15, 2008. A total of 38 EoIs were received, and information on the EoIs can be obtained from our web pages. Teams submitting successful EoIs were invited to submit a full proposal by June 15, 2009. The survey proposal evaluation and selection process was completed on 1 September 2009 and the ten successful Survey Science Projects have now been invited to proceed to the Design Study phase. For more information on participation in ASKAP science, please see the web pages or contact the ASKAP Project Scientists directly by sending email to atnf-askap-ps@atnf.csiro.au.

References

[1] Johnston, S. et al., 2007, PASA, 24, 174

[2] Johnston, S. et al., 2008, Exp. Astronomy, 22, 151

[3] Gupta, N. et al., 2008, ATNF SKA Memo Series, 21