A Polarization Sky Survey of the Universe's Magnetism (POSSUM)

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Summary

The Australian Square Kilometre Array Pathfinder (ASKAP) is a next-generation radio telescope currently under construction in outback Australia. ASKAP's large instantaneous field-of-view will allow it to survey the sky vastly faster than is possible with existing radio telescopes, allowing us to address fundamental questions about the origin and evolution of the Universe. Here we present the **Polarization Sky Survey of the Universe's Magnetism (POSSUM)**, one of the ten major ASKAP surveys now beginning their design study phases. In POSSUM, we plan to use ASKAP's unique survey capabilities to carry out a sensitive all-sky survey of polarization and Faraday rotation. With these data, we will be able to determine the 3D geometry of the Milky Way's magnetic field, to test dynamo and other models for magnetic field generation, and to carry out a comprehensive census of magnetic fields as a function of redshift in galaxies, in clusters and in the overall intergalactic medium.

1. The Australian SKA Pathfinder (ASKAP)

ASKAP is a next-generation US$100-million radio telescope currently under construction by CSIRO. ASKAP will consist of 36 12-metre dishes located in outback Western Australia (see Figure 1). At the focus of each ASKAP antenna will be a 0.7-1.8 GHz phased-array feed, which will provide a spectacular field-of-view covering 30 square degrees in a single pointing. This will give ASKAP a survey speed 100 times faster than any previous radio telescope. The first ASKAP antenna will arrive at the site in January 2010. Commissioning and early science with the Boolardy Engineering Test Array (BETA), consisting of six antennas, will begin in early 2011. Scientific programs with the full ASKAP array are expected to commence in late 2012. For more information on ASKAP, see http://www.atnf.csiro.au/projects/askap .

Image courtesy of Swinburne Astronomy Productions

Figure 1: CGI rendering of ASKAP antennas, superimposed on a photograph of the ASKAP site in outback Western Australia. At the focus of each dish is the phased-array feed that gives ASKAP its wide field of view.

2. POSSUM

The focus of ASKAP will be large surveys, requiring thousands of hours of observing time. In September 2009, CSIRO selected ten such surveys, and invited the corresponding teams carry out Design Studies aimed at developing the tools, algorithms & observing strategies needed to observe with this unique facility. One of the ten projects selected was the **"POlarization Sky Survey of the Universe's Magnetism" (POSSUM)**, in which we propose to make sensitive polarization images of the entire sky visible to ASKAP, covering more than 30 000 square degrees. During the Design Study phase, the POSSUM team will develop a detailed strategy for calibration and observing, along with a data-processing pipeline that will turn the raw data produced by ASKAP into publicly available science products.

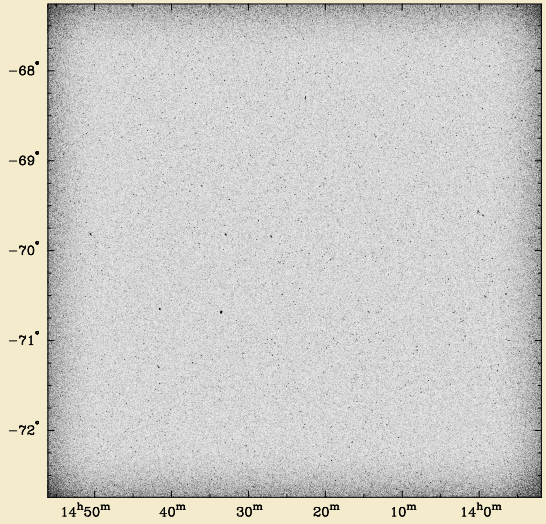

Figure 2: A simulated image of the polarized 1.4 GHz sky, as seen in a single 10-hour ASKAP pointing. The RMS noise is 10 μJy/beam at an angular resolution of 15 arcsec. The 30-deg^2 field contains approximately 3000 unresolved polarized extragalactic sources for which Faraday rotation measures can be determined.

3. Cosmic Magnetism with POSSUM

In POSSUM, we will coherently measure Faraday rotation for ~3 million polarized extragalactic radio sources across a 1150-1450 MHz observing band, providing an unprecedented "grid" of background rotation measures (RMs) at a sky density of 100 RMs/deg^2 (see Figure 2). This will allow us to address the following unresolved questions on the origin & evolution of cosmic magnetic fields:

• **What are the magneto-ionic properties of the ISM & its components?**
We will use angular correlations in the RMs of discrete background sources to provide a definitive characterization of magnetized ISM turbulence as a continuous function of l and b. We will be able to establish how the turbulent power spectrum is affected by local activity such as SNR shocks, star formation and supershell activity, on scales ranging from sub-parsec turbulence up to the global structure of the disc and spiral arms.

• **What is the geometry of the large-scale field of the Milky Way?**
The RMs of 3 million background radio sources, combined with the growing sample of pulsar RMs and extensive new surveys of infrared starlight polarization, will allow us to definitively identify the direction and pitch angle of magnetic fields in spiral arms and in inter-arm regions throughout our Galaxy, and thus distinguish between overall proposed geometries for the Milky Way's azimuthal field.

• **What are the magnetic properties of galaxies, clusters, & the IGM?**
We will use the intrinsic polarization of 1000s of galaxies to determine how galactic magnetic fields depend on rotation speed, Hubble type, degree of interaction and star-formation rate. The large extragalactic RM sample derived from POSSUM will also allow us to make the first detailed study of magnetic fields in the IGM. By calculating a two-point correlation of extragalactic RMs as a function of z, we aim to measure the strength and length scales of intergalactic magnetic fields, thus discriminating between primordial models vs. outflows as the seed for cosmic magnetism.

• **How do magnetic fields evolve with cosmic time?**
Cross-correlation of the RMs from POSSUM with redshift catalogues will yield ~30 000 RM - z pairs, a colossal expansion over the current small sample. This will allow the first robust characterization of magnetic field evolution in both normal and active galaxies as a function of cosmic epoch.

POSSUM is an open collaboration. If you are interested in contributing to the POSSUM Design Study, please contact bgaensler@usyd.edu.au .