1.1 Title and Abstract

POlarisation Sky Survey of the Universe's Magnetism (POSSUM)

Understanding the Universe is impossible without understanding magnetic fields. They fill interstellar space, affect the evolution of galaxies and galaxy clusters, contribute significantly to the total pressure of interstellar gas, are essential for the onset of star formation, and control the density and distribution of cosmic rays in the interstellar medium. Magnetic fields are also the key to the non-thermal Universe — by enabling processes such as anisotropic pressure support, particle acceleration and jet collimation, magnetism regulates the feedback that is vital for returning matter to the interstellar and intergalactic medium. However, it is still unclear how large-scale magnetic fields are generated and maintained.

We propose to use ASKAP's unique survey capabilities to dramatically improve our understanding of astrophysical magnetic fields. The **POlarisation Sky Survey of the Universe's Magnetism** (**POSSUM**) will consist of three tightly complementary experiments: a survey of 3 million extragalactic Faraday rotation measures over 30 000 square degrees ("POSSUM Wide"), a deep 30-deg^2 observation of polarisation from very faint radio sources ("POSSUM Deep"), and a 0.7–1.8 GHz all-sky survey of diffuse polarised emission ("Diffuse POSSUM"). With the resulting data, we can revolutionise our understanding of the ordered and turbulent components of the Milky Way's magnetic field, can test dynamo and other models for magnetic field generation in galaxies and clusters, and can carry out a comprehensive census of magnetic fields as a function of redshift in galaxies, active galactic nuclei, galaxy clusters and the overall intergalactic medium.

POSSUM will make a major contribution to the overall software and analysis effort for ASKAP, by producing a pipeline that effectively and reliably characterises the polarisation properties of focal plane arrays. This effort will also be crucial for the broader scientific outcomes of ASKAP, since both large continuum surveys and smaller guest science projects will need to apply the techniques developed within POSSUM in order to make their measurements. More generally, one of the main goals of ASKAP is to demonstrate the viability of the phased-array feed concept for the SKA. Successful calibration of continuum and polarisation data in POSSUM will therefore be a key part of ASKAP's pathfinding endeavour, and of the path to the full SKA.

An essential component of POSSUM will be the training of the next generation of radio astronomers who will ultimately become the user community for the SKA. During the POSSUM Design Phase, there will be numerous opportunities for students and early-career researchers to participate in science simulations of the polarised sky, to develop algorithms to calibrate the instrumental response to polarisation, and to take the lead in early science results with BETA. In particular, Australian-trained radio astronomy students have historically had a reputation for not just being scientifically competent but also having a deep understanding of the underlying instrumental and technical issues. By pro-actively identifying and encouraging PhD opportunities co-supervised by ATNF staff, POSSUM will provide a solid platform for ensuring that this legacy continues. Such an approach will foster an environment in which students can work closely on a daily basis with engineers, software developers and astronomers.

To summarise, cosmic magnetism is a vigorous and rapidly developing field. The surge of interest has been driven in large part by the prospect of dramatic new views of polarisation and Faraday rotation offered by the SKA and its pathfinders. POSSUM will deliver on these promises by offering a hundredfold improvement in survey yield over previous efforts, thus allowing the first meaningful study of the evolution of magnetic fields over cosmic history. POSSUM will not only open a stunning new window on the Magnetic Universe, but will put us on the path toward answering fundamental questions in physics and astrophysics with the SKA.