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Science with SKA phase I

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Abstract. Even in phase I, the Square Kilometer Array (SKA) should provide nearly an order of magnitude increase in point source sensitivity and mapping speed at long radio wavelengths compared to existing facilities. With the aim of beginning construction in 2018, this year the design consortia are converging on the final design for phase I, in parallel with the commencement of the SKA organisation science group activities. Eight science working group meetings have focused on the main areas to be addressed with this new facility, and we present an overview of projects that might be conducted when planned full phase I science operations begin in 2023. Finally, a conference will be held in Sicily in June, 2014, with the aim of generating an updated science case for phases I and II.

1. Baseline design and science goals

The currrent design for the SKA in phase I consists of three telescopes located at two radio quiet sites in Western Australia and the Karoo desert of South Africa (see Dewdney et al. 2013, *SKA1 System Baseline Design, Rev. 1*). With nearly 1000 35 m stations consisting of ~250 log periodic dipole antennas, the low frequency aperture array (LFAA) should operate between 50 and 350 MHz in Australia , alongside the SKA1 Survey telescope consisting of 96 (36 ASKAP and 60 15m SKA dishes) phased array feed equipped antennas operating at frequencies above 3 GHz. In South Africa, the 254 dishes (190 SKA and 64 MeerKAT) will be designed to support five single-pixel feed bands between 350 MHz and >20 GHz, with three of these deployed in phase I (SKA1 Mid).

Although the two key science drivers for phase I have been identified as the study of the 21 cm atomic hydrogen (HI) line during the Epoch of Reionization (EoR), and testing the general theory of relativity through pulsar surveys and subequent timing, a range of exciting science will be enabled by phase I. These science areas are described

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briefly here, while an opportunity exists for members of the global community to contribute to updating the SKA science case, which will be presented at a conference hosted in Giardini Naxos, Italy, during June of 2014[1].

The epoch of reionization: The detection and study of HI at redshifts $z > 6$ can provide key insight into the formation of the first stars and galaxies in the Universe. The LFAA should be capable of measuring the power spectra of 21cm HI brightness temperature fluctuations down to 50 MHz, while directly imaging ionized 'bubbles' of atomic gas at higher frequencies associated with QSO activity during the EoR.

Galaxy evolution, cosmology and dark energy: The survey speed of the SKA phase I will enable sensitive samples of extragalactic radio continuum sources over the entire sky visible from the two sites. By cross-correlating such surveys with the cosmic microwave background, one can measure the integrated Sachs-Wolfe (ISW) effect. HI emission line surveys, or HI 'intensity mapping' can measure the baryon acoustic oscillations, telling us about the growth of structure.

HI galaxy studies: Observations of the HI gas in galaxies can be used to constrain the evolution of the HI mass function out to redshifts $z \sim 1$ in phase I, and $z \sim 3$ with the full SKA. Resolved imaging of atomic gas in nearby galaxies reveals their kinematic properties, and probes the reservoir that can utimately fuel star-formation.

Continuum surveys: In addition to detection of the ISW effect, extragalactic continuum surveys can measure the evolution of obscured star-formation out to at least $z \sim 4$ in phase I, and possibly detect the signal due to weak lensing by foreground large-scale structure.

Radio transients: A rapidly growing field involves the exporation of time domain radio astronomy. Fast radio bursts (FRBs) have recently been discovered, and may be extragalactic in origin. In phase I, an all-sky transient survey every three days could discover ~5 new FRBs.

Cosmic magnetism: Magnetic fields in the Milky Way and distant galaxies will be probed by the SKA in phase I through observations of Faraday rotation and Zeeman splitting. In phase II, it is possible that magnetic fields in the diffuse intergalactic medium will be detected.

Pulsars surveys and tests of general relativity: Pulsar observations can provide one of the best strong-field tests of gravity. In phase I, the SKA Mid should discover ~2000 new millisecond pulsars, and timing of some fraction of these can be used to detect the stochastic cosmological gravitational wave background. Pulsar-black hole binaries will also provide tests of predictions made by general relativity.

The cradle of life: The SKA will play a key role in the study of prebiotic molecules in the Milky Way, and should be able to image cm size dust drains in debris disks on sub-arcsecond scales at frequencies above 10 GHz.

[1] *https://indico.skatelescope.org/conferenceDisplay.py?confId=270*