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The Square Kilometre Array (SKA)

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Abstract. The Square Kilometre Array is intended to be the centimeter- and meter-wavelength telescope for the 21st century. At long wavelengths, the SKA's key science projects include the search for highly redshifted hydrogen, including the signal from the epoch of re-ionization, and the search for the first supermassive black holes.

Keywords. atomic processes, line formation, instrumentation: interferometers, galaxies: active, cosmology: observations

1. Introduction

The Square Kilometre Array (SKA)† will be one of a suite of new, large astrophysics facilities for the 21st century, probing fundamental physics, the origin and evolution of the Universe, the structure of the Milky Way Galaxy, and the formation and distribution of planets. The SKA will be at least 50 times more sensitive than any other centimeter- to meter-wavelength telescope ever built. In addition to answering fundamental scientific questions, the vast increase in sensitivity provided by the SKA will also almost certainly lead to the discovery of new and totally unexpected celestial phenomena.

2. Key science

Five Key Science Projects for the SKA have been identified by the international community (Carilli & Rawlings 2004). These are: (*i*) the Cradle of Life and astrobiology (Lazio *et al.* (2004; (*ii*) Strong Field Tests of Gravity Using Pulsars and Black Holes (Kramer *et al.* 2004); (*iii*) the Origin and Evolution of Cosmic Magnetism (Gaensler *et al.* 2004); (*iv*) Galaxy Evolution, Cosmology, and Dark Energy (Rawlings *et al.* 2004); and (*v*) Probing the Dark Ages (Carilli *et al.* 2004). These Key Projects all represent unanswered questions in fundamental physics and astrophysics. Furthermore, each of these projects has been selected using the criterion that it represents science which is either unique to the SKA, or is a topic which is complementary to other data sets, but in which the SKA plays a key role (Gaensler 2004).

Observations will be conducted at wavelengths longer than 1 m in support of both the *Galaxy Evolution, Cosmology, and Dark Energy* and *Probing the Dark Ages* projects. A common goal of both of these projects is observing hydrogen at large redshifts ($z > 3$). For the galaxy evolution project, the goal would be to probe the assembly of the first structures, primarily by conducting an *unbiased* survey for damped Ly-α absorbers. Observations at these wavelengths are unaffected by dust obscuration, thus these observations can search in an unbiased manner for these H I-rich structures. At even larger redshifts, the SKA should have the sensitivity to image the formation of the structures during the Epoch of Reionization as the first luminous objects in the Universe heated the surrounding H I gas (Carilli 2006, these proceedings; Ciardi 2006, these proceedings).

† http://www.skatelescope.org/

As a secondary goal, the SKA will also conduct a survey for the first supermassive black holes. With the generally higher densities in the earlier Universe, as the first supermassive black holes accrete, any jets that they form are likely to result in radio-loud active galactic nuclei. A deep continuum survey should find radio-loud supermassive black holes out to their formation epoch.

3. SKA Reference Design

Over the past several years, initial design and prototyping efforts have focussed the design (Hall 2005) and have led to the recently adopted Reference Design. The Reference Design comprises both a set of specifications, informed by the Key Science Projects, as well as a concept for realizing those specifications.

The Reference Design emphasizes that, contrary to the popular notion of a telescope being the collecting area (a mirror or a reflecting parabolic dish), the most complex aspect of the SKA will be the data transmission and central processing facility. Radio signals will be fed to this central processing facility by one of three 'front-end' collectors, in a manner analogous to that of an optical telescope in which the mirror feeds visible-wavelength photons to one of a number of 'back-end' instruments. The three front-end collectors are: (*i*) an array of small-diameter antennas with 'smart feeds': the diameter is of the order of 10 m, and the feeds comprise phased arrays in the focal planes of the antennas for frequencies between 0.3 and 3 GHz, and wide-band feeds at higher frequencies up to 25 GHz; (*ii*) aperture array tiles: this innovative technology provides a 'radio fish-eye lens' for all-sky monitoring in the frequency range 0.3 up to 1 GHz and multiple independent observations; and (*iii*) an Epoch of Re-onization array: operating in the 0.1 to 0.3 GHz range, it will will make use of broad-band dipoles similar to those developed for the Low Frequency Array (LOFAR), the Milurea Wide-field Array (MWA), and the Long Wavelength Array (LWA). One of the motivations for this multiple front-end design is that the technology required to cover the full 0.1 to 25 GHz frequency range cannot be obtained by a single collector.

The Reference Design also describes the distribution of the collecting area: 20 % should be within a 1 km diameter region, 50 % should be within 5 km of the core site, 75 % within 150 km of the core, with the remainder on maximum baselines of about 3000 km.

The current timeline for the SKA calls for construction to begin in the early part of the next decade, with a facility having approximately 10 % of the collecting area of the full telescope, probably a relatively compact array operating at frequencies around 1 GHz. Over the rest of the decade, the telescope would be expanded to longer baselines and higher frequencies.

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References

Carilli, C. L., Furlanetto, S., Briggs, F., *et al.* 2004, *New Astron. Revs.*, 48, 1029

Carilli, C. L., & Rawlings, S. (eds.) 2004, *Science with the Square Kilometre Array*, *New Astron. Rev.*, 48

Gaensler, B. M. 2004, *Key Science Projects for the SKA*, *SKA Memo Series*, No. 44

Gaensler, B. M., Beck, R., & Feretti, L. 2004, *New Astron. Revs.* 48, 1003

Hall, P. 2005, *The Square Kilometre Array: An Engineering Perspective* (Springer-Verlag: Berlin)

Kramer, M., Cordes, J. M., Backer, D. C., *et al.* 2004, *New Astron. Revs.* 48, 993

Lazio, T. J. W., Tarter, J. C., & Wilner, D. J. 2004, *New Astron. Revs.*, 48, 985

Rawlings, S., Abdalla, F. B., Bridle, S. L., *et al.* 2004, *New Astron. Revs.*, 48, 1013