

## Abstract for CD/EoR Science Chapter

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The SKA CD/EoR Science Team proposes to write a (lead) chapter that summarizes the capabilities of SKA1 in context of the current baseline design (and proposed modifications thereof) in detecting and quantifying the brightness temperature of HI from  $z \sim 6$  to  $z \sim 27$ . The chapter will also address future capabilities of SKA2. The proposed chapter will be accompanied by a series of “sub”-chapters, that go in to greater detail on specific science topics outlined in the lead chapter, although all chapters can be read stand-alone.

With this set of chapters (see appendix) we propose to cover the Cosmic Dawn and Epoch of Reionization science cases that SKA1/2 can address via a broad range of observables: e.g. brightness-temperature variance, higher-order statics, power-spectra, n-point correlations, tomographic cubes (i.e. images), HI-absorption spectra, cross-correlation etc.

In the lead chapter, we propose to address a potential strawman CD/EoR project including outlining an potential observational program, different observing strategies, data-processing and access, RFI excision, calibration and imaging, foreground removal, signal extraction and the computational demands involved, outlining potential issues and avenues to address them.

Finally the lead and sub-chapters will discuss how and to what level HI observations can address questions about the physics and sources responsible for the CD/EoR: e.g. (X-ray) heating, (WF) coupling, feedback, recombination, ionization, photon sinks, bulk-flows, light-cone effects, redshift-space distortions, metalicity, etc, etc. and the sources of ionization (e.g. stars, AGN), and connect these to stellar, ISM/IGM, galaxy and structure formation and evolution in the Universe at  $z < 6$ .

We plan to discuss the impact of changes to the current baseline design on the different science cases and the ability to control systematics, as well as roll-out strategies for early science.

We note that authorship is not restricted to the SKA CD/EoR Science Team, and we aim for an inclusive authorship for each of the chapters.

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## Proposed lead chapter outline

1. Introduction
2. General overview of relevant physics during CD/EoR:

- (X-ray) heating, (WF) coupling, feedback, recombination, photon sinks, ionization, bulk-flows, light-cone effects, redshift-space distortions, metallicity, gas and radiation physics
- 3. Sources of heating, radiation, feedback and ionization
  - Stars, X-ray binaries, AGN, dark-matter annihilation, etc.
- 4. Observables via 21-cm brightness temperature  $T_b$  e.g.:
  - Variance/higher-order statistics
  - Power-spectra (1/2/3D)
  - Higher-order statistics/n-point correlations
  - Tomography/Images
  - Bubbles and HI topology
  - 21-cm absorption
- 5. Effects of varying input physics/sources on CD/EoR observables
- 6. Current SKA1-low BD relevant for CD/EoR Science Case
- 7. Straw-man CD/EoR Survey with SKA1
  - Outline survey specs and data-products
  - Data requirements/Access Modes/User Cases
  - Optimal observing strategies
  - Survey requirements/specs: different set-up for different cases/Multi-beaming
  - Data processing: from raw data to data cubes: calibration + imaging
  - $T_b$ -signal extraction and analysis
- 8. Expected outcome of SKA1 strawman CD/EoR Survey
  - What will we learn about the physics and sources during the CD/EoR
  - Cosmology – Synergy with Cosmology ST
  - Expected uncertainties and limits
- 9. Synergy with other surveys/Cross-correlations
- 10. Impact of an SKA1 re/descope: The -30% sensitivity case  
Role-out and early science.
- 11. Limits of SKA1 and prospects for SKA2
- 12. Summary & Conclusions

**Some proposed sub-chapters** (*possible merging after SWG discussion*)

- a. EoR fluctuations
- b. EoR imaging
- c. EoR cosmology
- d. Global signal
- e. Imaging of bubbles from galaxies and AGN
- f. Reionization
- g. First galaxies - Ly $\alpha$ , X-ray, spin temperature fluctuations
- h. 21cm Forest
- i. Bulk flows and end of dark ages
- j. Correlations and cross-correlations e.g. kSZ
- k. EoR Foregrounds Removal
- l. EoR modeling and simulations
- m. Constraining CD/EoR physics with HI data.
- n. Synergy with JWST + TMT + ALMA + SKA - first galaxies, Euclid
- o. CO/CII intensity mapping during EoR