EoR simulation pipeline

1. Background: What is the Epoch of Reionisation (EoR).
2. Overview of the Epoch of Reionisation simulation pipeline.
3. Challenges that need to be overcome to improve the pipeline.
4. SDP applications.
1. Background: The EoR signal

First stars form

Frequency/time
1. Background: The EoR signal

Coupling processes drive 21-cm signal into absorption

Image credit: Pritchard & Loeb 2012
1. Background: The EoR signal

Frequency/ time

Heating process start to dominate

Image credit: Pritchard & Loeb 2012
1. Background: The EoR signal

Reionization of hydrogen forges holes in the 21-cm signal which grow with time.
1. Background: The EoR signal

Challenge is to overcome foregrounds 3-4 orders of magnitude larger.
2. Overview of EoR pipeline

- Simulated sky model
- Telescope model
- Visibility set
- Image
2. Overview of EoR pipeline

- Simulated sky model
- Telescope model
  - OSKAR
    - B. Mort, F. Dulwich
    - [http://www.oerc.ox.ac.uk/~ska/oskar2/](http://www.oerc.ox.ac.uk/~ska/oskar2/)
- Visibility set
- Image
2. Overview of EoR pipeline

Simulated sky model ➔ OSKAR (B. Mort, F. Dulwich)

Telescope model ➔ Visibility set ➔ CASA (National Radio Astronomy Observatory)

Image
2. Overview of EoR pipeline

Simulated sky model → OSKAR
OSKAR → Visibility set
Visibility set → CASA
CASA → Image

Telescope model → Foreground removal/avoidance
Foreground removal/avoidance → Data analysis

OSKAR
B. Mort, F. Dulwich
(http://www.oerc.ox.ac.uk/~ska/oskar2/)

CASA
National Radio Astronomy Observatory

Data analysis

C. Watkinson (UCL) - The EoR Pipeline
2. Input - telescope model

SKA rebaselined
2. Input - sky model

Foregrounds

Cosmological signal

~10 degrees
3. Challenges to overcome

1. Modelling and mitigating point sources and ionospheric effects.

2. Radio Frequency Interference is not currently modelled within the pipeline.

3. Foreground removal techniques are not currently optimised to deal with the chromaticity of the instrument. Dealt to date by fixing the PSF at a fixed (lower) frequency, enforcing lower resolution for many frequencies. This is a poor approximation and throws information away.
4. SDP application

Even assuming time (over ~10s) and frequency averaging (~100kHz) of visibilities and that analysis can be running at all times, *SKA-EoR will produce 22 Gb/s of data.*

This quantity of data still requires the use of regional data centres for the community to access the data.

*EoR pipeline can be used to establish the optimum time and frequency averaging* for EoR science.
5. Status (imminent)

- Simulated cosmological signal
- Simulated foregrounds
- Telescope model
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  National Radio Astronomy Observatory
- Image
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5. Status (imminent)

Cosmological signal (light cone generation) → OSKAR → Visibility set → Image → Data analysis

Foregrounds (V. Jelic simulations) → OSKAR → Visibility set → Image → Data analysis

Telescope model → Foreground removal - GMCA (eventually others) → Data analysis

OSKAR
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CASA
National Radio Astronomy Observatory

Data analysis
5. Status (planned)

- Cosmological signal (light cone generation)
- Foregrounds (V. Jelic simulations)
- Telescope model

**Visibility set**

**OSKAR**
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**CASA**
National Radio Astronomy Observatory

**Image**

**Foreground removal - GMCA (eventually others)**

Data analysis
6. Conclusions

1. There is an established EoR simulation pipeline.
2. This will soon be consolidated to a point where the community can submit simulated cubes (cMpc$^3$) directly from EoR simulations and be provided with a simulated observation of this.
3. Data compression is essential and an EoR simulation pipeline will be useful to identify the optimal compression.
4. However there are still improvements that need to be made to the pipeline.