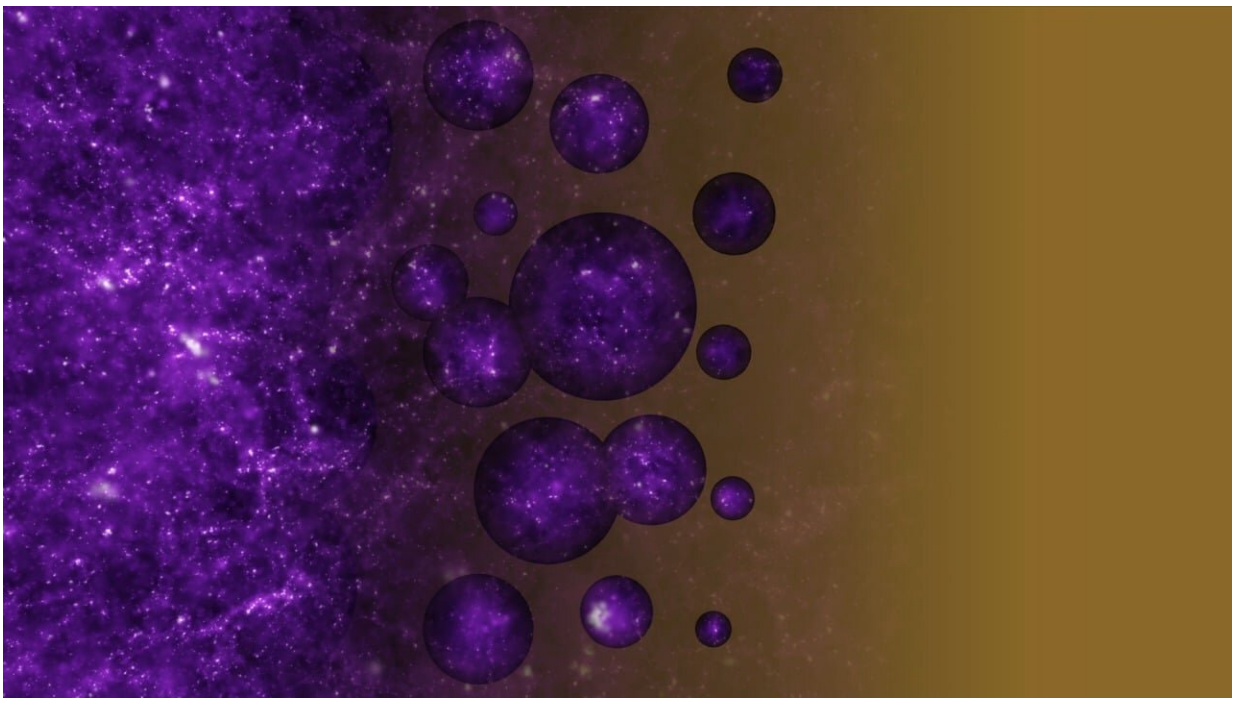
1000 hours with the Square Kilometer Array may be our best hope to finally see Cosmic Dawn

June 13 2025, by Mark Thompson



This still image shows the timeline running from the Big Bang on the right, towards the present on the left. In the middle is the Reionization Period, when the initial bubbles caused the Cosmic Dawn. Credit: NASA

Scientists have created a computer simulation that mimics what the Square Kilometer Array Low-frequency (SKA-Low) telescope will see

when it searches for signals from the universe's earliest epochs. This simulation represents a major step forward in preparing for one of astronomy's most ambitious goals: directly observing the Cosmic Dawn and Epoch of Reionization. The research is published on the *arXiv* preprint server.

The Cosmic Dawn refers to the universe's first sunrise—a period roughly 200–600 million years after the Big Bang when the very first stars began to shine. Before this era, the universe was shrouded in a "dark age" filled with cool, neutral hydrogen gas but no sources of light. As the Cosmic Dawn evolved, the neutral hydrogen began to emit a faint radio signal at a wavelength of 21 centimeters. As the universe expanded, this signal became "redshifted" to lower frequencies that we can detect today with radio telescopes.

The Epoch of Reionization followed, when ultraviolet light from early stars began ionizing the surrounding hydrogen gas, creating bubbles of charged particles that gradually merged together. This process fundamentally changed the universe's structure and marked the end of the "dark ages."

Detecting these ancient signals presents enormous technical challenges. The simulation corresponds to a deep integration pointing over the 106 MHz–196 MHz frequency range, representing an incredibly long observation time needed to collect enough data. The signal is extraordinarily weak, thousands of times fainter than the foreground "noise" from our own galaxy and other sources.

The simulation created by the team led by Anna Bonaldi from the SKA Observatory at Jodrell Bank in the UK includes multiple components that real observations will encounter: the actual Cosmic Dawn signal, powerful radio sources both inside and outside the telescope's field of view, emissions from our own Milky Way galaxy, and various sources of

measurement errors including atmospheric interference and instrument calibration issues.

This realistic simulation serves as a crucial testing ground for developing techniques to separate the faint signal from overwhelming foreground interference. The exceptional sensitivity of the SKA will allow observations of the Cosmic Dawn and Epoch of Reionization (CD/EoR) in unprecedented detail, both spectrally and spatially. This wealth of information is buried under galactic and extragalactic foregrounds, which must be removed accurately.

The research team included sources ranging from extremely bright radio galaxies (over 5 Jy at 150 MHz) down to sources a million times fainter (1 microJy), along with detailed models of our galaxy's radio emission and small-scale structures in interstellar space. Note the brightness of a radio source is measured in Jansky units (Jy).

When SKA-Low becomes operational, it will be the most sensitive low frequency radio telescope ever built, specifically designed to detect these elusive signals from the universe's infancy. Once up and running, the SKA-Low telescope will be able to take the best possible measurements of the universe's first light sources. It should also be able to take snapshots of hydrogen emissions before, during, and after reionization.

More information: Anna Bonaldi et al, SKA-Low simulations for a cosmic dawn/epoch of reionisation deep field, *arXiv* (2025). DOI: 10.48550/arxiv.2506.09533

Provided by Universe Today