The observable signature of late heating of the Universe during cosmic reionization

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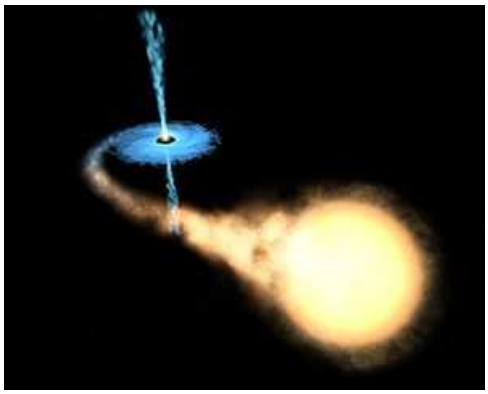
Brief summary

One of the exciting frontiers in astronomy is the era of the formation of the first stars. Since the universe was filled with hydrogen atoms at that time, the most promising method for observing the epoch of the first stars is by measuring the characteristic emission of hydrogen at a wavelength of 21 cm , which falls in the range of radio waves.

Our new study reveals that black holes that formed from the first stars in the universe heated the gas throughout space later than previously thought, also imprinting a clear signature in these radio waves, which astronomers can now search for.

The first stars.



The first black-hole binaries.

Cosmic archaeology

Astronomers explore our distant past, billions of years back in time. Unlike archaeologists on Earth, however, who can only study remnants of the past, astronomers can see the past directly. It takes the light from distant objects a long time to reach us, and we see these objects as they were back when they emitted their light. This means that if astronomers look out far enough, they can see the first stars as they actually were in the early universe. Thus, the new finding that cosmic heating occurred later than previously thought means that observers do not have to look out as far, and it will be easier to see this cosmic milestone.

Cosmic heating may offer a way to directly probe the earliest black holes, since it was likely driven by stellar systems called “black-hole binaries.” These are pairs of stars in which the larger star ended its life with a supernova explosion that left a black-hole remnant in its place. Gas from the companion star is pulled in towards the black hole, gets ripped apart in the strong gravity, and emits high-energy X-ray radiation. This radiation reaches large distances, and is believed to have re-heated the cosmic gas, after it had cooled down as a result of the original cosmic expansion. The novelty in the new research is the delay of this heating.

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The cosmic radio show

It was previously believed that the heating occurred very early, but we discovered that this standard picture depends sensitively on the precise energy with which the X-rays come out. Taking into account up-to-date observations of nearby black-hole binaries changes the expectations for the history of cosmic heating. It results in a new prediction of an early time (when the universe was only about 400 million years old, compared to its current age of 14 billion years) at which the sky was uniformly filled with radio waves emitted by the hydrogen gas.

Several large international groups have built and begun operating new arrays of radio telescopes, in order to detect the expected radio waves from hydrogen in the early universe. These arrays have been designed under the assumption that cosmic heating occurred too early to see, so that instead the arrays can only search for a later cosmic event, in which radiation from stars broke up the hydrogen atoms out in the space between galaxies ("cosmic reionization"). The new discovery overturns the common view and implies that these radio telescopes may also detect the tell-tale signs of cosmic heating by the earliest black holes.