Seeing the birth of the universe in an atom of hydrogen

September 5 2012

Windows to the past, stars can unveil the history of our universe, currently estimated to be 14 billion years old. The farther away the star, the older it is—and the oldest stars are the most difficult to detect. Current telescopes can only see galaxies about 700 million years old, and only when the galaxy is unusually large or as the result of a big event like a stellar explosion.

Now, an international team of scientists led by researchers at Tel Aviv University have developed a method for detecting galaxies of stars that formed when the universe was in its infancy, during the first 180 million years of its existence. "The method is able to observe stars that were

previously believed too old to find," says Prof. Rennan Barkana of TAU's School of Physics and Astronomy.

Published in the journal *Nature*, the researchers' method uses radio telescopes to seek out radio waves emitted by hydrogen atoms, which were abundant in the early days of the universe. Emitting waves measuring about eight inches (21 centimeters) long, the atoms reflect the radiation of the stars, making their emission detectable by radio telescopes, explains Prof. Barkana. This development opens the way to learning more about the universe's oldest galaxies.

Reading signals from the past

According to Prof. Barkana, these waves show a specific pattern in the sky, a clear signature of the early galaxies, which were one-millionth the size of galaxies today. Differences in the motion of dark matter and gas from the early period of the universe, which affect the formation of stars , produce a specific fluctuation pattern that makes it much easier to distinguish these early waves from bright local radio emissions.

The intensity of waves from this early era depends on the temperature of the gas, allowing researchers to begin to piece together a rough map of the galaxies in an area of the sky. If the gas is very hot, it means that there are many stars there; if cooler, there are fewer stars, explains Prof. Barkana.

These initial steps into the mysterious origins of the universe will allow radio astronomers to reconstruct for the first time what the early universe looked like, specifically in terms of the distribution of stars and galaxies across the sky, he believes.

A new era

This field of astronomical research, now being called "21-centimeter cosmology," is just getting underway. Five different international collaborations are building radio telescopes to detect these types of emissions, currently focusing on the era around 500 million years after the Big Bang. Equipment can also be specifically designed for detecting signals from the earlier eras, says Prof. Barkana. He hopes that this area of research will illuminate the enigmatic period between the birth of the universe and modern times, and allow for the opportunity to test predictions about the early days of the universe.

"We know a lot about the pristine universe, and we know a lot about the universe today. There is an unknown era in between when there was hot gas and the first formation of stars. Now, we are going into this era and into the unknown," says Prof. Barkana. He expects surprises along the way, for example involving the properties of early stars, and that observations will reveal a more complicated cosmological reality than was predicted by their models.

Provided by Tel Aviv University

Citation: Seeing the birth of the universe in an atom of hydrogen (2012, September 5) retrieved 25 April 2024 from https://phys.org/news/2012-09-birth-universe-atom-hydrogen.html

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