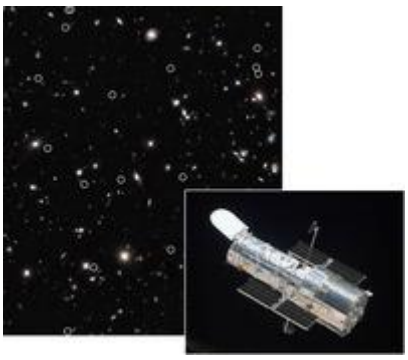
How the Early Universe Cleared Away the Fog

by Yudhijit Bhattacharjee on 3 November 2010, 2:33 PM |



Fog busters. Galaxies from the early universe, such as these faint objects imaged by the Hubble telescope (*inset*), helped to ionize the universe and make it transparent by the time it was a billion years old.

Credit: R. J. McLure and J. S. Dunlop/Univ. of Edinburgh, R. S. (Hubble inset) NASA

About 300,000 years after the big bang, the universe was like a smoke-filled chamber from which light could not escape. By the time the universe was a billion years old, the smoke—actually a gas of light-trapping hydrogen—had cleared almost entirely, allowing stars and galaxies to become visible. But exactly what cut through the haze has been one of the big questions in astrophysics. Now, by analyzing images taken by the Hubble Space Telescope, researchers have come close to confirming their best guess: the smoke was cleared away by a blaze of ultraviolet radiation from the earliest galaxies.

About 300,000 years after the big bang, the first atoms formed as protons combined with electrons to make hydrogen. Because hydrogen atoms trap light, the young universe entered its "dark ages." Then about a billion years later, some sort of radiation had ionized the hydrogen, turning it into a transparent broth of electrons and ions over a period of several hundred million years; the period is known as the Epoch of Reionization.

Although researchers had always suspected radiation from galaxies as the primary source of ionization energy, they did not have much evidence to back up the idea. That's why some alternate mechanisms for ionization weren't ruled out—such as intense light emitted by early black holes as they gobbled up matter, or the energy released by the dark matter particles annihilating one another. The problem was that astronomers had hardly any data from the early universe, which until recently was too faint even for Hubble to get any good pictures of.

The Hubble's new Wide Field Camera 3 (WFC3), mounted on the space telescope in 2009, changed all that. It took pictures showing faint galaxies from a mere 600 million to 800 million years after the big bang, including one reported 2 weeks ago as the most distant object observed to date. And now a team lead by Brant Robertson, an astrophysicist at the California Institute of Technology in Pasadena, has used images from WFC3 to pin much of the responsibility for reionization on light from those early galaxies.

By counting up the number of such galaxies and extrapolating to fainter galaxies that can't be spotted in the pictures but likely exist, Robertson and his colleagues estimated the number of ultraviolet photons emitted by these early objects. Then, they calculated what fraction of these photons made it all the way to the intergalactic medium, which at the time was hydrogen. From the calculations, the researchers determined that there were enough photons to ionize almost all of the hydrogen by the time the universe became transparent.

Although researchers have yet to learn much about the stellar populations within these galaxies, one thing they do know is that "the galaxies are extremely blue," says Robertson. That indicates that a lot of new stars are forming inside them, and "they are producing lots of ionizing photons," he says.

However, Robertson points out that the uncertainty in his team's estimation of how many faint galaxies there are is still too high to definitively conclude that radiation from galaxies was enough to do all the ionizing work. In order to get more certainty, he and his fellow authors want to use WFC3 to take even deeper pictures of space by pointing at the same patch of sky for longer durations. That will help spot the fainter galaxies, Robertson says, eliminating the need for extrapolation.

Martin Haehnelt, an astrophysicist at the University of Cambridge in the United Kingdom who was not involved in the work, agrees that further observations are needed. But both he and Volker Bromm, an astrophysicist at the University of Texas, Austin, say the work is a significant advance toward understanding reionization. Says Haehnelt, "The new observations with Hubble WFC-3 are a huge step forward."

http://news.sciencemag.org/sciencenow/2010/11/how-the-early-universe-cleared-a.html