SCIENCE NEWS of the week

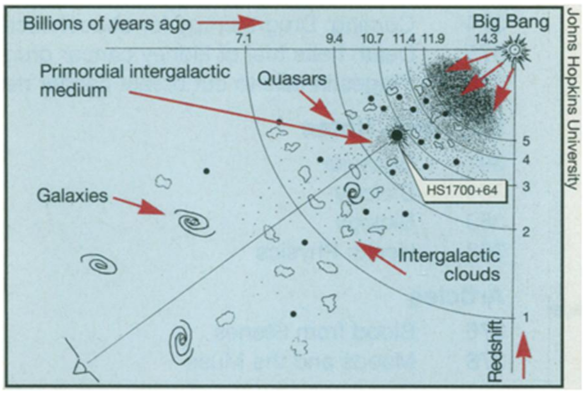
Eyeing Evidence of Primordial Helium

Astronomers this week reported that they have found the unmistakable fingerprints of ionized helium in the early universe. The finding, a confirmation of earlier hints, supports a key prediction of the Big Bang theory, which holds that hydrogen, helium, and trace amounts of lithium were forged in the first few minutes after the birth of the universe.

The helium discovery came as researchers at last glimpsed the tenuous fog of gas that fills the space between galaxies in the young cosmos. This gas, the diffuse intergalactic medium, has eluded detection for more than 25 years.

Using the new observations, principal investigator Arthur F. Davidsen and his colleagues at Johns Hopkins University in Baltimore also estimated the total abundance of both helium and hydrogen in the early universe. Although these gases had very low densities, they account for 5 to 10 times as much mass as the known population of stars and galaxies, the researchers say. This excess is consistent with a Big Bang prediction that baryons—the protons and neutrons that make up ordinary particles—should constitute not just the visible matter in the universe, but also a few percent of the invisible, or dark, matter.

Davidsen and his colleagues Gerard A. Kriss and Wei Zheng presented their findings at a meeting of the American Astronomical Society in Pittsburgh.



Johns Hopkins University

Diagram shows beacon of light emanating from the quasar HS1700+64.

The new work provides "absolute evidence that at early times there was a lot of helium around," says cosmologist Gary Steigman of Ohio State University in Columbus.

Davidsen and his collaborators base their results on the detection of characteristic gaps in the spectrum of ultraviolet light emitted by a distant quasar. As the beacon of light traverses the vast expanse of space between the quasar and Earth, it encounters intergalactic hydrogen and helium. Gas completely ionized by the quasar light can't absorb any more radiation. The light therefore passes unimpeded, as if it were traveling through a transparent window. This appears to be the case for diffuse hydrogen, which is easily stripped of its one electron.

But it takes more energy to ionize a helium atom, which has two electrons. Although the quasar beacon fully ionizes most of the helium it encounters, some of the atoms manage to retain one of their electrons. When the radiation passes through singly ionized helium, the ions absorb light of a particular wavelength, leaving behind a fingerprint—a dark line, or gap, in the quasar's spectrum. Because of the redshift of light caused by the expansion of the universe, gaps due to helium ions at different distances along the line of sight to the quasar will appear at different wavelengths to an observer on Earth. Thus, the helium ions collectively create a series of dark absorption lines in the quasar spectrum.

The Hopkins Ultraviolet Telescope (HUT), part of the Astro 2 Observatory that flew aboard the space shuttle last March (SN: 3/4/95, p.133), recorded a series of such gaps in the spectrum of the quasar HS1700+64, which lies about 10 billion light-years from Earth. Light from this quasar illuminates the universe as it appeared about 10 billion years ago, when the cosmos was roughly one-third its current age.

The singly ionized helium detected by HUT represents only a tiny fraction of the total amount of helium that resided in the early universe, since most of the gas is completely ionized. "We are only seeing the tail of the dog," notes Davidsen. "[But] it's enough of a tail to know that it's a very big dog."

HUT's ability to analyze the quasar light at high resolution enabled the team to distinguish absorption from two intergalactic sources: denser clouds of neutral hydrogen and helium, and the more diffuse distribution of singly ionized helium. In contrast, says Davidsen, a previous detection by the Hubble Space Telescope could not differentiate between the two (SN: 7/9/94, p.21).

The HUT findings, he adds, support the notion that quasars, rather than galaxies, provide the ultraviolet glow bathing the youthful cosmos. — *R. Cowen*

Mixing air into sand to get fluidlike flow

One way to get sand or some other granular solid to flow like a liquid is by shaking it up. Industrial engineers have long used such a "fluidized bed" strategy to keep powders moving during the manufacture of pharmaceuticals and other products.

Now, physicist Robert P. Behringer and his coworkers at Duke University in Durham, N.C., have demonstrated quantitatively that air plays a central role in this process. Their experiments show that just a little bit of air trapped in a granular material allows the shaken grains of the solid to travel in the distinctive swirling patterns characteristic of convective fluid flow (SN: 6/26/93, p.405).

Jim Wallace/Duke News Service

Behringer (left) and Eric Van Doorn with apparatus for studying how air trapped in vigorously shaken sand enables the resulting air-sand mixture to flow like a liquid.

The researchers report their findings in the June 5 Physical Review Letters.

To study this convective motion, Behringer and his colleagues confined sand grains or glass beads to the narrow gap between two cylinders, one placed inside the other. When such an apparatus, partially filled with a granular material, is repeatedly shaken up and down, the enclosed material's upper surface develops a slant across the entire ring. In other words, particles heap up on one side of the ring that confines them.

This heaping results from the upward motion of particles within the material to the top of the pile. The particles then avalanche down the slope to reach the ring's opposite side before resuming their motion back up to the top.

The researchers found that for grains smaller than 1 millimeter in diameter, the amount of heaping decreases rapidly when air pressure is reduced below 1 percent of atmospheric pressure. Essentially no heaping occurs at zero pressure, suggesting that granular fluid flow requires the presence of air. For larger particles, air tends to leak out instead of getting trapped. — *I. Peterson*