Computer model captures missing matter

To explain how the universe evolved from a smooth soup of subatomic particles to a lumpy collection of galaxies, astronomers have had to accept that the vast majority of matter, more than 95 percent, assumes the form of invisible material known as dark matter. While they puzzle over the nature of dark matter, another cosmic mystery has often been overlooked. Researchers have yet to find most of the baryons—ordinary matter such as neutrons and protons—in the present-day cosmos.

New computer simulations suggest that the missing baryons are indeed present but remain hidden from view because they radiate at wavelengths notoriously difficult to detect. Jeremiah P. Ostriker of Princeton University presented the findings last week at a meeting of the American Astronomical Society in San Diego.

Calculations of the concentrations of hydrogen, helium, and a few other light elements forged in the aftermath of the Big Bang indicate that baryons add up to a few percent of the total amount of matter in the universe. Studies of quasar light that has passed through distant clouds of hydrogen reveal a similar total.

The most distant clouds date from a time when the cosmos was only a few billion years old. By analyzing how much of the quasar light is absorbed by the clouds, astronomers can deduce the density of baryons at early times (SN: 5/18/96, p. 309). The newest analysis indicates that baryons account for 4 percent of the critical density—the density required to keep the cosmos poised between eventual collapse and perpetual expansion. David Tytler of the University of California, San Diego reported this result at last week's meeting.

Baryons produced in the infant universe can't easily be destroyed, if at all, so when astronomers search for them in the nearby reaches of the cosmos they should find the same density. But their observations at wavelengths ranging from radio waves to X rays invariably come up short.

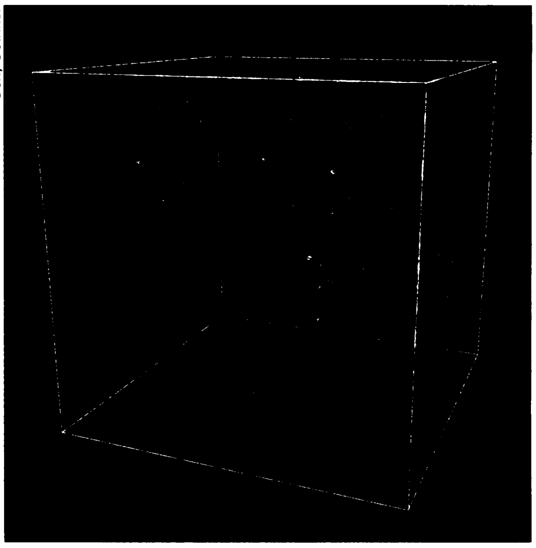
Computer models of the growth of structure in the universe developed by Ostriker and Renyue Cen of Princeton suggest that half of all the baryons in the cosmos are now at a temperature between 100,000 and several million kelvins. At those temperatures, the baryons are in a diffuse gas that radiates extreme-ultraviolet light and low-energy X rays. Other research groups have reported similar results.

"This is a very odd temperature range, in that it's very hard to observe," says Richard Mushotzky of NASA's Goddard Space Flight Center in Greenbelt, Md. He notes that dust in the Milky Way absorbs extreme-ultraviolet light and that the X-ray glow from our galaxy overwhelms the faint emissions from the baryonic gas.

New detectors may find the gas if it contains trace amounts of metals such as neon and magnesium, says Mushotzky. Such metals would absorb characteristic wavelengths of light from a background quasar and would also emit identifiable wavelengths. Other detectors that could distinguish the X-ray glow of baryonic gas from the glow of the Milky Way are also under development.

"Theoreticians are telling us that most of the [ordinary] stuff that we think we understand in the universe is in this phase that we never thought existed," says Mushotzky. "Now we have to go out and observe it." —*R. Cowen*

Cen, Ostriker



Computer model shows that a large fraction of ordinary matter (green filaments) in the cosmos today glows at temperatures between 100,000 and several million kelvins.

Toads can't tell guys from gals

Kiesecker

A male western toad will grab anything that moves. Here, luckily, he has clasped a female.

Male western toads aren't totally undiscriminating, but they don't seem able to distinguish one sex from the other. They keep the species going with the philosophy: "If it moves—especially if it's big—grab it and mate."

Experiments offering males a choice of partners have revealed the details of a trial-and-error mating system, report Adolfo Marco from the University of Salamanca in Spain and his colleagues.

The toads have only a few days each year to mate, returning by the hundreds to the same spot every spring. According to some theorists, such a mating fest, where males literally scramble for partners, should encourage the evolution of specific ways to pick the best mates.

"We speculate, however, that under some conditions scramble competition may not favour effective sex and mate recognition," Marco's team says in the June Animal Behaviour. If making a pass at the wrong sex doesn't waste much time or energy, where's the pressure for improvement? Western toads, at least, seem to manage quite well.

The team studied the toads that crowd into a small section of Lost Lake in Oregon for four to six nights of mating. "They're constantly jumping on one another," says coauthor Joseph M. Kiesecker from the Yale School of Forestry and Environmental Studies in New Haven, Conn. As one of the males moves, the others think it's a female and they tackle it, he adds.

When a male gets grabbed by mistake, he protests. The researchers describe his characteristic series of peeps as "birdlike twittering calls." The mistaken suitor lets go quickly. Kiesecker has never seen one male clasp another for more than three seconds.

A female doesn't emit this release call when grabbed, so a male holds on for hours, sometimes days. The female drags him along until she releases her eggs.

When researchers offered the toads a choice, males picked large females over smaller ones. "But they can't make the distinction between males and females," Kiesecker reports.

That's not so strange, he says. The females of this species generally grow larger than males, and the biggest females, in theory, lay the biggest clutches of eggs. Getting fuddled on the male-female thing, however, causes only a few seconds of inconvenience.

"The more general question," says Paul Verrell from Washington State University in Pullman, "is, 'How choosy are males?'"

The standard answer has been that males of most species invest little in reproduction, so they are not too selective about their efforts. "We expect males to try to mate with the end of a beer bottle or the toe of your boot," Verrell says. During recent years, however, he has seen a shift in theory, recognizing a larger role for male selectiveness. —*S. Milius*