Most ordinary matter in universe has not yet been detected according to new study by UCSD astronomers

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To most astronomers, it's something of an embarrassment that no one has been able to identify or detect 90 percent of the mass in the universe--the mysterious dark matter.

Now, two astronomers from the University of California, San Diego suggest another reason to be red-faced: they might not be seeing nearly 90 percent of the universe's ordinary matter either.

This conclusion, based on new measurements of the total mass of all the baryon particles--protons and neutrons--in the universe, was presented today by David Tytler, a physics professor with UCSD's Center for Astrophysics and Space Sciences, at the annual meeting of the American Astronomical Society meeting in Tucson, Arizona.

"Added together, all the matter in galaxies, and gas clouds accounts for only about a fifth of what we estimate," said Tytler. "If we're right, then about 86 percent of the baryonic matter in the universe has not yet been found."

Together with his colleague Dr. Xiao-Ming Fan, also of UCSD, Tytler described a four-year search--first with the Lick Observatory telescope in San Jose, Calif. and then the Keck telescope in Hawaii--to find a quasar whose light passed through a suitably "cool and primordial" gas cloud on its way to earth. Quasars, engimatic objects that exist at the far reaches of the galaxy, are among the strongest sources of radio emissions in the sky.

When the scientists finally found their cloud, Tytler said, an analysis of the quasar's light allowed them to determine the ratio of deuterium to hydrogen (D/H) in the cloud, which in turn provided a measure of the total mass of baryons in the universe.

The significance of D/H in calculating universal mass arises from predictions based on the Big Bang theory. When the Big Bang occurred, the theory goes, virtually all of the baryon mass existed in the form of free protons and neutrons. Within seconds, however, as the embryonic universe expanded and cooled, many of these particles began to combine and soon formed the two most common elemental forms in the universe--hydrogen and helium--and, in a far lesser amount--deuterium, or heavy hydrogen. But, before the universe had cooled further, much of these primordial deuterium nuclei combined with one another to create more helium.

The formation of helium from nascent deuterium is the key to calculating the universe's total mass, for the more dense the original baryonic soup, the more deuterium nuclei collide and combine and the more helium that's created. Thus, the amount of deuterium remaining from the Big Bang is a measure of how many baryons there were to begin with; the more deuterium, in the form of D/H, the lower the initial mass of baryons, and vice versa.

"We've understood the importance of D/H for a long time," Tytler said, "but the difficulty has been measuring it accurately. You can determine the content of deuterium in the Milky Way quite easily, but this is of little value. Most of the gas in galaxies has at some point been in stars, and stars destroy deuterium.

"You can also measure the concentration of deuterium on earth," he continued, "but here too the numbers are unreliable. Deuterium combines with oxygen to form water more readily than ordinary hydrogen, so the amount of deuterium on the earth is enriched compared to the concentration in the galaxy."

Accordingly, Tytler and Fan began their search for a cloud of gas deep in intergalactic space, a cloud that had never been part of a galaxy and would thus contain the primordial mixture of elements, and that lay along the line of sight of a quasar.

They examined a total of 20 quasars in detail before finding one that would yield the data they wanted.

"Space is full of primordial gas clouds, and many lie between us and the light from quasars," Tytler said. "However, most aren't suitable for what we wanted to measure. Hydrogen and deuterium absorb light a slightly different wavelengths, but most clouds are hot and relatively dense, and the weak signal from deuterium is swamped by the much larger hydrogen signal.

"But, we finally found one that was relatively cool and not so dense. Moreover, the cloud contained very little carbon or silicon, which indicated that it was nearly pristine. The gas had not been cycled through stars where these elements are made."

As expected, the D/H ratio the UCSD scientists found indicated that the mass of the baryons in the universe is far too small to stop the expansion of the universe, a finding in agreement with prevailing theory. However, their data did turn up something very unexpected.

"When we compared our value for the density of baryons with accepted values for the amount of matter in the visible universe, we found a huge discrepancy," Tytler said. Roughly 90 percent of the expected baryonic mass was missing.

"We can't explain the discrepancy but we can offer two possibilities," he added. "The more exotic one is black holes; all the missing baryons could be there. More likely, however, is that all this matter might be in hot, low density gas clouds we don't yet know of. We're looking for them now."

Another group of astronomers carried out similar D/H measurements on a different gas cloud last year and concluded that the baryonic mass of the universe was about six times less than what Tytler and Fan found. "We are confident we are correct," Tytler said, "but to be certain we'll just have to get back to the Keck telescope and find more of these clouds and quasars."

Written by Dennis Blakelee