NASA finds missing cosmic matter

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Found: 7 percent of the mass of the universe. Missing since: 10 billion years ago.

Consider one more astronomical mystery solved. Scientists have located a sizeable chunk of the universe that seemed to be missing since back when the stars first formed. It's floating in super-hot rivers of gas, invisible to the naked eye, surrounding galaxies like our own. And a completely different kind of mystery matter -- dark matter -- may have put it there. The results appear in the current issue of the journal Nature.

To make this latest discovery, astronomers at Ohio State University and their colleagues used NASA's Chandra X-ray Observatory to take the highest-quality spectrum of its type ever made.

Though astronomers had previously detected the rivers of gas with X-ray telescopes, this is the first time that the gas has been studied in enough detail to calculate how much of it is out there. The amount of gas matches the amount of material that went missing 10 billion years ago, said Smita Mathur, associate professor of astronomy at Ohio State.

She and doctoral student Rik Williams did this work with astronomers at the Harvard-Smithsonian Center for Astrophysics (CfA), the University of California, Berkeley, the Instituto de Astronomia in Mexico, and the Massachusetts Institute of Technology. The lead author on the paper is Fabrizio Nicastro of CfA.

According to current theories, when the universe began, it contained a

certain amount of normal matter, a cache of protons and neutrons that today make up all normal atoms -- “stuff” as we know it.

Astronomers can use optical telescopes to look back in time and see what happened to the normal atoms, called baryons. Around 10 billion years ago, when half of the baryons became stars and galaxies and lit up the sky, the other half just seemed to disappear.

This new study shows that the missing baryons are still out there, Mathur said, they’re just floating in gas that is too hot to see with an optical telescope.

The gas that surrounds our galaxy, for example, is 100 times hotter than the sun -- so hot that it shines in high-energy X-rays instead of lower-energy visible light.

In 2002, Mathur and her colleagues used Chandra’s X-ray telescope to gather the first evidence that the gas was made of baryons. The image they obtained was a spectrum, a measurement of the different wavelengths of X-rays emanating from the material. But to prove that there was enough material there to account for the all the missing baryons, they knew they needed to take a better spectrum with the telescope.

“Those first results were tantalizing, but not foolproof. The signal-to-noise ratio in the spectrum was just not good enough,” Mathur said.

They needed a bright light source to pump up the signal, one located on the other side of the gas as viewed from Earth, so that the light shined directly through the gas. They found their source in a quasar, located in the constellation Ursa Major -- the Big Dipper.

Astronomers believe that quasars are galaxies with very massive black

holes in the center. The black holes in quasars don't just suck material in, they also shoot material out in a high-speed jet. The jet glows brightly, and the result is an intense beam of light -- exactly what Mathur and her colleagues needed to take their picture.

The astronomers decided to use the light from Markarian 421, one of the brightest quasars known. On two days -- one in October 2002 and another in July 2003 -- when Markarian 421 was at its brightest and the beam of light was pointing right at Earth, Mathur's team took two very high quality X-ray spectra of the intervening gas.

Judging by the high signal-to-noise ratio of the data, the astronomers believe that one of their images is the best X-ray spectrum ever taken.

That spectrum isn't what most people would consider a pretty picture -- it's really just a graph of energy levels of light that penetrated the gas -- but to Mathur it's absolutely beautiful, because it proved definitively that there are enough baryons -- "normal" atoms -- out there to account for the missing mass.

"This is such a wonderful spectrum that there is just no doubt about it," she said.

Once they had the new spectra, the astronomers were able to calculate the density of baryons in the gas, and confirmed that the amount of material matched the missing matter they were searching for.

As to how the missing baryons ended up where they are, Mathur suspects that they were drawn there by the gravity of a different kind of matter, known as dark matter. Astronomers know that some unseen material provides most of the gravity of the universe, though they disagree on what dark matter is actually made of.

If Mathur and her colleagues are right, then their finding supports a dramatic theory: that dark matter provides a kind of backbone to the universe, where the structure of normal matter like galaxies follows an underlying structure of dark matter.

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