significant progress has been made in the past year in the treatment of HIV-1 infection, it would be wrong to believe that we are close to a cure for AIDS."

Haase and other researchers contend that mathematical studies of viral kinetics have provided as much information as they ever will about whether it is possible to eradicate the virus. "The only way to answer the question now is to discontinue therapy and measure the virus," says Haase. Ho's group and other labs now have studies under way that should do just that during the next year or so. But Ho stresses that he is not at all certain that the virus will ever be vanquished. "The end game can be as hard as the beginning game or the middle game—and you can lose," says Ho, who formerly was a serious chess player. "I think for HIV, this last bit is the hardest."

–Jon Cohen

ASTRONOMY

Primordial Gas: Fog Not Clouds

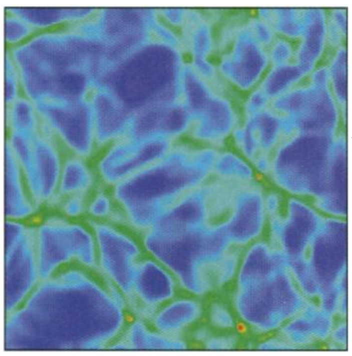
Astronomers lost in an intergalactic forest finally may have found a way out. Two astrophysicists appear to have cleared up the puzzling distribution of tenuous gas in the distant universe, which produces a "forest" of dark lines in the spectra of the bright, remote objects called quasars. By assuming that there is a ubiquitous, undulating fog of hydrogen and helium in the vast reaches of space between galaxies, Arthur Davidsen and HongGuang Bi of Johns Hopkins University not only provide a new explanation for these dark lines, they also account for a key part of the universe's "missing matter."

The new picture, published in the current issue of *Astrophysical Journal*, replaces a model that attributed the forest of lines to discrete gas clouds along the path from Earth to each quasar. Recent computer simulations of how structures took shape in the early universe had cast doubt on the picture, however, and so had the inability of the hypothetical clouds to account for all the hydrogen and other normal matter that cosmologists believe is left over from the big bang. Bi and Davidsen's theory agrees with simulations and provides a home for the missing matter—and it explains the forest of lines to a high degree of accuracy. "[The fact] that observation and theory agree so well means that this is a success—a big success," says David Weinberg, a computational astrophysicist at Ohio State University.

In the early 1970s, astronomers discovered these lines by the hundreds in the ultraviolet region of quasar spectra and dubbed them the Lyman-α forest. Theorists guessed that each line was the shadow of a cloud of hydrogen gas between the quasar and Earth, absorbing light at a specific wavelength. The clouds would be moving away from Earth at different speeds because of the expansion of the universe, and so the Doppler effect would shift each absorption band by a different amount. Hundreds of discrete, spherical hydrogen clouds, each with a different Doppler shift, could explain the whole forest of lines.

But computer models of the universe, which build in assumptions about the amount and types of matter created in the big bang, then trace how the matter coalesces under gravity, couldn't reproduce the clouds. So Davidsen and Bi tried a new approach. They looked at the consequences of an extremely simple mathematical assumption about the intergalactic medium: that the logarithm of its density has a normal, or bell-curve, distribution, meaning that the gas has denser and more tenuous regions but isn't broken into discrete clouds.

A decade ago, the idea would have faced a struggle, explains Davidsen, because the discrete lines in the Lyman-α forest seem to say that the space between the absorbing regions is empty. But astronomers now have reason to think that intervening matter could simply be invisible. The intergalactic medium contains other elements besides hydrogen, among them helium and carbon, and their shadows in the quasar spectra indicate that the medium is highly ionized: Radiation from quasars has stripped away electrons from most of the atoms.


NORMAN ET AL./NCSA

Tendrils of fog. A new picture of the intergalactic medium, as simulated by computer.

As astrophysicist Donald York of the University of Chicago explains, "Ionized hydrogen has no signature; only neutral hydrogen does." Without an electron, a bare hydrogen nucleus can't absorb a photon, so a region of tenuous, ionized hydrogen should leave no trace in the Lyman-α forest. Only in the denser regions would enough neutral atoms remain to create a line.

When Davidsen and Bi used a computer to calculate the precise forest of lines that would be seen in quasar light passing through their continuous medium, they found a close match to the Lyman-α forest. Regions of high density absorb the light at many different wavelengths, much as the discrete clouds did, but they are larger, less dense, and less contrived than the clouds. "There hasn't been a theory which can explain [the lines]," says Mike Norman of the University of Illinois, Urbana-Champaign. "Now that theoretical model is in hand."

Norman, like Weinberg, runs supercomputer simulations of cosmic-structure growth. He too is impressed by the agreement between the Davidsen-Bi picture and the simulation results. The latest computer models generate nothing like the discrete clouds of the earlier picture; instead, they naturally evolve a mass distribution that mimics the Lyman-α forest. Says Norman, "By assuming a distribution for the density, Davidsen and Bi bypassed 500 hours of supercomputer time."

The new picture offers an answer to one of the long-standing problems of astronomy. As David Schramm, an astrophysicist at the University of Chicago, puts it: "Where are the bulk of the baryons?"

According to the big bang theory, the universe should contain several times more baryons—particles of ordinary matter, such as protons and neutrons—than we can see in the stars and galaxies. If gas in the intergalactic medium is in the form of discrete, light-absorbing clouds, there can't be enough of it to account for the baryon deficit. But with highly ionized, and therefore invisible, hydrogen distributed between the dense patches, the diffuse intergalactic medium could account for nearly all the baryonic matter in the early universe—the full amount that had been missing.

Not all astronomers accept the picture, neat as it is. "I don't think that the [baryon-density] value is as high as their model's value," says Lennox Cowie, an astrophysicist at the University of Hawaii. Cowie thinks the new theory and the computer simulations overestimate the amount of ionizing radiation in the early universe and thus the number of invisible baryons. "It's a nice piece of work," he says. "Still, the question's not settled yet."

Others, however, are ready to lay the matter to rest. "We finally feel we understand the Lyman-α forest," says Neal Katz, an astrophysicist at the University of Massachusetts. "Now we can use it as a tool" to study the elusive matter that produces it.

–Charles Seife

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