Astronomy

Ron Cowen reports from Pittsburgh at a meeting of the American Astronomical Society

Detecting gas clouds in cosmic voids

Empty space isn't so empty after all. Astronomers have detected clouds of hydrogen gas in what were thought to be giant voids, hundreds of light-years across, between clusters of galaxies.

The hydrogen clouds may represent the outer, gaseous halos of galaxies too faint to show up directly on telescope images, notes study coauthor John T. Stocke of the University of Colorado, Boulder. Alternatively, the clouds may consist of pristine material, forged a few minutes after the birth of the universe, that never formed stars or coalesced into galaxies.

During the 1970s and 1980s, several teams of researchers established that galaxies in relatively nearby parts of the universe arrange themselves in thin sheets separated by giant bubbles or voids (SN: 11/25/89, p.340). Using the Hubble Space Telescope's Goddard high-resolution spectrograph, Stocke and his collaborators examined some of these seemingly empty regions of intergalactic space by analyzing the light from quasars that lie just behind the voids.

When the quasar light passes through a gas cloud, atoms in the cloud absorb some of the radiation, producing a characteristic gap in the spectra recorded by the Hubble detector. Clouds that lie at different distances along the line of sight to the quasar produce absorption gaps at different wavelengths, as seen by an observer on Earth.

Stocke and his coworkers, including Boulder astronomers J. Michael Shull and Steven V. Penton, found that two of the nine hydrogen clouds they detected lie in what appear to be empty regions of space. Extrapolating from their observations, the team estimates that low-density hydrogen clouds could collectively contain as much mass as the known population of galaxies.

But they note that most clouds do seem to avoid the voids, confirming that these regions are nearly—though not entirely—free of matter. Any theory of galaxy formation must still come to terms with this distribution of material, the researchers note.

New spin on galaxy formation

In studying distant gas clouds that may rank among the universe's earliest examples of galaxies in the making, astronomers have uncovered a puzzling property. Observed as they appeared when the cosmos was only 20 percent of its current age, these gaseous objects seem to rotate about twice as fast as several popular models of galaxy formation predict.

Their speed of rotation—about 220 to 250 kilometers per second at their edge—is comparable to that of the Milky Way today. Study collaborator Jason X. Prochaska says he finds it perplexing that galaxies had such a high rotation rate early in the universe. If fledgling galaxies in the youthful cosmos already had the spin of today's Milky Way, their increased rotation rate after several billion years of evolution might cause them to break apart instead of forming the galaxies seen in nearby regions of the modern universe.

"If this result holds up as we look at more [distant] objects, it is going to change the way people look at galaxy formation," says study coauthor Arthur M. Wolfe.

He and Prochaska, both of the University of California, San Diego, used the 10-meter W.M. Keck Telescope atop Hawaii's Mauna Kea to examine the gas clouds. Wolfe and Prochaska inferred the presence of the faraway clouds by analyzing the absorption of light emitted by quasars behind them. The researchers found characteristic asymmetries in the shape of absorption lines created by silicon, nickel, and iron in the clouds. These asymmetries, believed to signify rotation, indicate that the clouds spin at an unexpectedly high rate, Wolfe and Prochaska assert.

Probing the members of globular clusters

When a white dwarf, a type of compact star, pulls matter from a close stellar companion, periodic fireworks can result. Over the years, astronomers have found a multitude of these pairs of mercurial stars, known as cataclysmic variables. Now, scientists have for the first time obtained spectra of tightly orbiting binary stars, which may well be cataclysmic variables, within the crowded confines of a globular star cluster.

Jonathan E. Grindlay of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass., Adrienne Cool of the University of California, Berkeley, and their colleagues began their study in 1992, training the unrepaired Hubble Space Telescope on the Milky Way globular cluster NGC 6397. The intensity of hydrogen emission in the Hubble images hinted that several of the stars might qualify as cataclysmic variables.

Earlier this year, the group reexamined these stars with the faint-object spectrograph aboard the refurbished Hubble. Hubble's repaired optics allow astronomers to obtain the spectra of individual stars in a crowded cluster. The spectra of three of the stars revealed emissions from hydrogen and ionized helium—a dead giveaway, according to the team, of activity associated with cataclysmic variables.

The high temperatures of these atoms and ions hint that the newly detected cataclysmic variables are magnetic, Grindlay notes. That's curious, he adds, because less than 10 percent of known cataclysmic variables have significant magnetic fields.

Strong magnetic fields are often associated with rapid stellar rotation. Grindlay speculates that in the crowded environment of a globular cluster, close encounters between neighboring stars may boost stellar rotation rates, generating large magnetic fields. Some of these stars may then evolve into magnetized white dwarfs that end up in cataclysmic variables.

The Hubble observations also suggest that cataclysmic variables are far more abundant in the cores of globular clusters than in other, lower-density regions of our galaxy, Grindlay says. If that conclusion proves true, it would have important implications for the evolution of globular clusters.

When a star in a globular cluster gets too close to a cataclysmic variable, two outcomes are possible, he notes. The cataclysmic variable may impart a gravitational kick that sends the star fleeing, or the star will trade places with and eject the white dwarf's original partner. Either way, he notes, binary stars act as cosmic eggbeaters, stirring up a globular cluster and preventing it from collapsing to form a black hole.

A star with jets?

Beta Lyrae ranks as one of the most widely studied stars in the heavens. Historical observations of this binary system, which consists of one star that donates mass to a disk of material encircling a companion, date to 1785. Now, a shuttleborne telescope has given astronomers their first three-dimensional view of Beta Lyrae. The data hint that jets of hot gas squirt out of the poles of the star within the disk.

Astronomers can't view the interior of Beta Lyrae directly because the disk blocks it, notes Kenneth H. Nordsieck of the University of Wisconsin-Madison. But gas lying above and below the poles of the central star polarizes light from Beta Lyrae, reflecting some of it toward Earth and enabling scientists to peek inside the binary system.

In conjunction with ground-based observations of polarized visible light, data from the Wisconsin Ultraviolet Photopolarimeter Experiment, which flew aboard the Astro 2 Observatory last March, revealed the presence of such polar gas clouds. Nordsieck says that by analogy with much larger systems that have accretion disks, such as quasars, the clouds represent gas jets propelled by Beta Lyrae's disk.