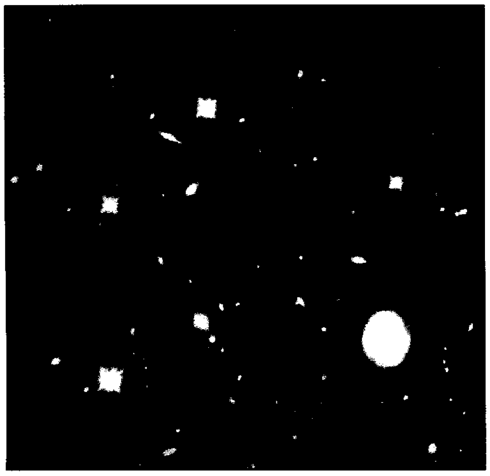


Far frontier. Data from the Hubble Deep Field South observation may have revealed the most galaxies yet.

ranges. In very distant galaxies, for example, interstellar hydrogen gas blots out a part of the ultraviolet spectrum. By comparing observations at different colors, astronomers can estimate where this drop-off falls in the spectrum of a distant galaxy, and thus how much its light has been red-shifted. Because even ultraviolet light is shifted all the way into the infrared for very distant galaxies, Lanzetta and Yahil's analysis relied heavily on observations by Hubble's NICMOS infrared camera.

Such "photometric" redshift measurements are considered less reliable than measurements based on a spectrum. Yahil notes, for example, that some of the candidate high-redshift galaxies could be old elliptical galaxies—whose light is very red—at smaller distances. Charles Steidel of the California Institute of Technology in Pasadena, who pioneered the photometric redshift technique a few years ago, sees "no reason to doubt the results," but says, "You have to have a lot of faith at these high redshifts." And theorist Jim Peebles of Princeton University says, "Lanzetta and Yahil have demonstrated a good track record for redshift estimates in the [Hubble Deep Field North], so I expect people will take the observations in the south seriously, but not [consider them] definitive."

Confirming the results could take the Next Generation Space Telescope, an orbiting infrared telescope to be launched in 2007, although Lanzetta and Yahil have floated plans to build an array of cut-rate telescopes, with giant mirrors made of spinning mercury, to gather the light needed to make spectra of distant galaxy candidates. But if the findings do hold up, they will add to mounting evidence that the early universe was a far more active place than astronomers had thought.

When the Hubble Space Telescope observed Deep Field North, just over 3 years ago, the NICMOS camera wasn't installed yet, and the most remote objects remained invisible because all of their light is shifted into the infrared. Based on Deep Field North, astronomers concluded that few stars had formed at redshifts larger than 3. "That notion is beginning to crumble," says Yahil. Steidel, for example, has found evidence of rapid star formation at redshifts greater than 4 (*Science*, 4 December 1998, p. 1806). And Yahil now says, "At the moment, it's even not clear if we see a drop in the star formation rate between redshifts of 5 and 10."

How the new data will affect theorists' picture of cosmic structure formation isn't clear yet. "I think the conclusions are not a problem for the usual ideas if the galaxies at a redshift of 10 are quite rare," says Peebles. But as astronomers push farther out and back in time, the usual ideas may come under more and more pressure.

–GOVERT SCHILLING

Govert Schilling is an astronomy writer in Utrecht, the Netherlands.

ASTROPHYSICS

Microwave Hump Reveals Flat Universe

PARIS—The physicist Richard Feynman once said that even if a camel's tail appeared under the flap of a tent, he wouldn't believe in the camel until he could see the hump. Now, astrophysicists may be seeing the full dimensions of a hump in measurements of the cosmic microwave background (CMB), a faint microwave glow on the sky that is the afterglow of the big bang. The observations, made by two microwave telescopes at the South Pole and announced here in mid-December at the Texas Symposium on Relativistic Astrophysics and Cosmology, are likely to be far more welcome than a camel in a tent. The hump appears to be a long-sought sign that the cosmos contains the full complement of matter and energy that theorists have long postulated.

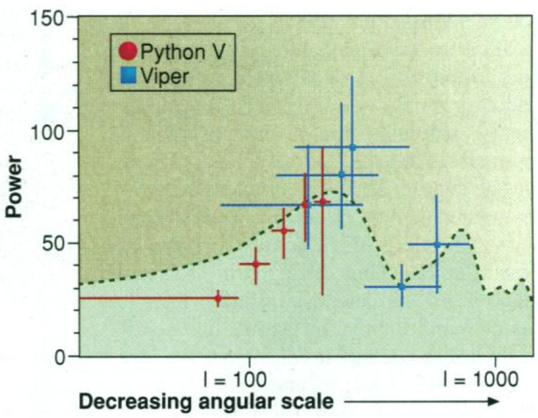
The hump is actually a measure of ripples in the CMB, which record slight irregularities in the matter and energy of the early universe. The apparent size of the irregularities indicates the shape of the universe, just as the apparent size of an object viewed through a magnifying glass says something about the shape of the glass. In a plot of "power," or abundance, of ripples of various sizes, a peak at a size of about 1 degree on the sky would indicate a universe that is spatially "flat."

A flat universe—a universe with a "critical density" of matter and energy—is a key prediction of the best-accepted theory of how the big bang got started, called inflation. In a universe consisting entirely of matter, the critical density of matter would be just enough for gravity to slow its expansion to a stop after infinite time. But if a major ingredient of the universe is a hypothetical energy in empty space, it could be flat with much less matter, and its expansion could even be speeding up, as recent measurements of distant exploding stars suggest it is (see *Science*, 18 December 1998, p. 2156).

At least two earlier sets of measurements had hinted at the 1-degree hump. One set, made from a telescope in Saskatoon, Canada, showed points on the power plot rising from large angular scales to a possible peak at 1 degree; another, made by the Cambridge Anisotropy Telescope in the United Kingdom, seemed to show a drop on the far side of the peak at smaller scales. But astrophysicists wanted more details of the hump before believing it—details that the South Pole experiments, Python and Viper, now appear to have provided.

The two experiments, part of the Center for Astrophysical Research in Antarctica, take advantage of the thin, dry air at the South Pole for a clear view of the CMB. They surveyed opposite sides of the peak, Viper looking for ripples on scales from 1/6 degree up to a degree, and Python for ripples measuring from one degree up to several degrees. Their findings dovetail, too. "We definitely see rising power up to this [1-degree] scale," said Python's Kimberly Coble of the University of Chicago. "We see a decrease" at large scales, said Viper's Jeff Peterson, of Carnegie Mellon University.

Both results are preliminary, although Python members say they are preparing a paper on the results. But Neta Bahcall of Princeton University, who is not involved in the work, said, "It's a very nice observation. They do see a rise; they do see something falling down. It's very suggestive." –JAMES GLANZ



Telltale peak. The Python and Viper experiments show that fluctuations in the cosmic background radiation are concentrated at the size predicted (dashed line) for a "flat" universe.

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