ASTRONOMY

Starbirth, Gamma Blast Hint At Active Early Universe

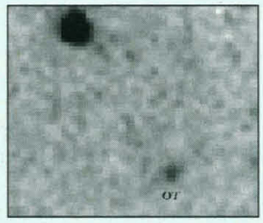
Astronomers thought starbirth subsided at great distances, but new observations suggest that stars were forming and exploding as far as telescopes can see

Somewhere beyond the greatest distances and earliest times that telescopes can reach lie the dark ages of the universe, the era between the big bang and the birth of the first stars. Those dreary times are even more remote than anyone had imagined, two recent developments suggest. In one, astronomers found frenzied star formation as far back as they could see. In another, a tremendous flash of gamma rays, among the brightest of these events ever recorded, may have originated at an even greater distance.

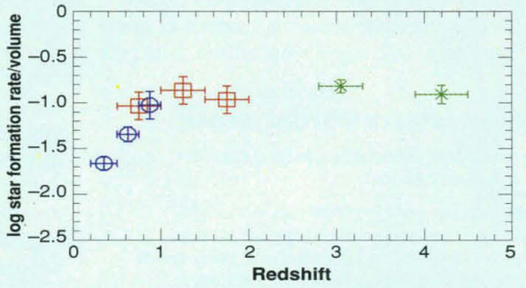
These hints that the early universe was a much more active place than anyone suspected contradict the evidence of the Hubble Deep Field (HDF), a 10-day space telescope exposure that NASA unveiled 3 years ago, which probed as far back in time as possible in a tiny speck of the sky. The HDF suggested that star formation slows at the greatest distances, implying that the dark ages might lie just beyond the farthest reaches probed by the image. The new evidence hints, instead, that the HDF may have probed an unusually vacant region of the distant universe. The astronomers involved caution that contradictory evidence could emerge at any time. But for now all eyes are on the work, some of which has only recently been presented in talks and posted on the Los Alamos preprint server (xxx.lanl.gov). The developments are "tremendously exciting," says Dale Frail of the National Radio Astronomy Observatory (NRAO) in Socorro, New Mexico.

Posted just last week was a paper by Charles Steidel of the California Institute of Technology and four colleagues describing star-formation rates far out in space and back into the cosmic past. Steidel began by estimating "redshifts"—a measure of distance—for about 1500 galaxies observed with several telescopes in an area of the sky that included the HDF but was about 200 times larger. Interstellar gases screen out the shortest wavelengths of light from distant galaxies, producing a characteristic cutoff in the spectrum called the Lyman break. By estimating how much the expansion of the universe had displaced each galaxy's Lyman break toward the red end of the spectrum, Steidel was able to gauge its redshift. Then, by recording the amount of ultraviolet light that hot young stars emit from the galaxies and allowing for some dimming by dust, Steidel worked out the star-formation rate as a function of redshift.

"We were surprised by what we found," says Steidel. The rate did not decline for as far back as they could see—out to a redshift of more than 4, corresponding to roughly 13 billion years ago, perhaps 90% of the way back to the big bang. "It's just a long plateau," he says. That conclusion jibes with hints from other wavelength bands (*Science*, 17 July, p. 320), but it conflicts with earlier work that focused only on the HDF—work whose results acquired enormous influence, despite the warnings of some of the people who did the analysis.



The HDF analysis, led by Piero Madau of the Space Telescope Science Institute (STScI) in Baltimore—Steidel was a co-author—found a steep decline in star formation at redshifts greater than 3. The observations had the advantage of using the Hubble Space Telescope, which could pick up intrinsically fainter galaxies than the ground-based telescopes of the latest Steidel work. But the conclusions rested on just 13 galaxies at a redshift of 4, compared to 244 for Steidel's work. "The issue with the HDF is that it's a small region of the sky," says Madau. "HDF might have gone through a region empty of galaxies, a void."



Nonstop action. New data on star formation (green x's) show no falloff in the early universe, where a titanic gamma burst left a visible afterglow (marked OT, in inset).

Madau says he wants to wait for analyses of a second deep field image, made in the southern sky (*Science*, 27 November, p. 1621), to draw firmer conclusions about whether the original HDF is a statistical oddball, but that for now, "I think [Steidel] is probably right." Steidel says that his rate could even represent a lower limit, because his analysis would have missed any light blocked completely by dust, rather than just dimmed. The influence of the HDF work "does reflect how people don't read the fine print," says STScI's Mark Dickinson, who is a co-author on both papers.

The second hint of an active young cosmos came last month, when STScI's Andrew Fruchter posted a paper on the Los Alamos server suggesting that a gamma ray burst (GRB) seen on 29 March originated at a redshift of about 5. GRBs—mysterious, seconds-long flashes of gamma rays—cannot be ranged directly, even though they briefly outshine all other known objects in the universe. But they often have "afterglows" at optical wavelengths, like the embers of a campfire, whose redshifts can be found. Last spring, two Caltech researchers made headlines by announcing a then-record redshift of 3.4 for a GRB (*Science*, 24 April, p. 514).

Then, after the 29 March GRB, a team led by Greg Taylor and Frail of NRAO saw an afterglow in radio wavelengths and fixed its position precisely enough to lead several teams to the optical afterglow. Fruchter applied the Lyman-break method to the optical data and concluded that the burst probably originated at a redshift of 5. Because the event was among the 4% brightest of all GRBs seen from Earth, such a distance points to an explosive energy at the source that is "just staggering," says Frail.

He and others caution that a heavy dose of dust could mimic the Lyman-break absorption. But detailed modeling by Daniel Reichart and others at the University of Chicago supports the notion that the redshift is still around 5. At that distance, the intensity of the GRB adds further support to scenarios for these celestial explosions in which a powerful magnetic field surrounding the gamma ray source channels the rays in one direction, beaming them across the cosmos like a searchlight that is sometimes pointed toward Earth, says Jonathan Katz of Washington University in St. Louis.

If GRBs are connected with the violent deaths of the massive, short-lived stars found in star-forming regions, as some researchers have suggested, then Fruchter's distant event "is totally consistent with what we're finding," says Steidel. But he warns that the trend of an active young universe could prove just as fragile as earlier conclusions about these remote times. **–JAMES GLANZ**

CREDITS: (TOP) A. FRUCHTER; (BOTTOM) C. STEIDEL