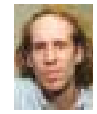

Onward to the First Stars

Looking as far back in time as ever before, astronomers are searching for the first objects to form.

by Christopher Wanjek

"Are we there yet?" So goes the most common question ever to be uttered by a child from the backseat of a car. The answer is inevitably "no" and, with my parents, anyway, followed by, "Uh, I think it's time for your cough medication again."

For Hubble Space Telescope scientists, the answer is, "We're almost there." We are almost at the point of viewing the first stars to form in the Universe.

On 9 March, scientists at the Space Telescope Science Institute (STScI) in Baltimore, home of the Hubble telescope, unveiled the deepest image of the Universe yet—a mere pinpoint on the sky containing nearly 10,000 galaxies, some at a distance of over 13.2 billion light-years. This Hubble Ultra Deep Field reveals the first galaxies to emerge, about 500 million years after the Big Bang.

The dim light, comparable to the glow of a firefly on the Moon, is one ten-billionth times fainter than what the human eye can detect. Scientists pointed Hubble at these galaxies for one million seconds to collect enough light to make a clear image. The first stars formed just before the first galaxies, scientists say, about 100 million years earlier. We can't quite see them yet. These stars have since died, but we may be able to detect their 13.5 billion-year-old light with Hubble's successor, the James Webb Space Telescope, scheduled for launch in 2011.

STScI took the opportunity to turn this latest of fantastic Hubble images into a battle cry to keep Hubble alive. Maryland Senator Barbara Mikulski was on hand to unveil the image, and she pledged to fight for Hubble's survival. For budget and safety reasons, NASA plans to forgo the fourth and final servicing mission in 2006, meaning the satellite might not be able to operate through 2007 (see "The Future of the Hubble Space Telescope," Mar/Apr, p. 46). This would leave at least a four-year gap before the arrival the next space-based optical and near-infrared telescope.

Hubble scientists are visibly frustrated. Just when they've reached the first galaxies and are approaching the first stars (one reddish object in the Ultra Deep Field might be the most distant object ever seen), Hubble's future is in jeopardy.

The Hubble Ultra Deep Field. Image courtesy of NASA, ESA, S. Beckwith (STScI), and the HUDF Team.

Yet great opportunities abound in other wavebands. The Wilkinson Microwave Anisotropy Probe (WMAP) has captured an earlier period of the Universe, about 13.7 billion years ago, the afterglow of the Big Bang called the cosmic microwave background. Then came the so-called dark ages about a million years after the Big Bang, an epoch when there was no light: the Big Bang was "over" and structure hadn't formed. Scientists are divided over what first emerged from the dark ages, so it is unclear what kind of instrument is needed to find these objects.

WMAP data and independent computer simulations suggest that there was a great release of energy at the end of the dark ages, at about 200 million years after the Big Bang (at redshift 15-20). Avi Loeb of Harvard University and others say that stars, and, subsequently, supernovae, provided this energy. Jeremiah Ostriker of Princeton University and others say that stars cannot supply the type of energy "required" by WMAP data and that something else—likely our old friend the black hole—is needed. Tom Abel of Pennsylvania State University has used computer models to show the evolution of some type of early conglomeration, about 100,000 solar masses of "stuff" with an extremely massive (+200 solar-mass) star at the center that could, conceivably, collapse into a massive black hole.

Nascent star and black-hole activity is usually enshrouded in dust. X rays are able to penetrate this dust, but optical and near-infrared light cannot. So if the first objects to form were black holes—precursors to quasars—then Hubble and Webb may not be able to see them.

How about the Chandra X-ray Observatory? Are we there yet? Not quite. Chandra has an impressive 0.5-arcsecond resolution, but even a 10-million-second, deep-field observation by it would barely be enough to get to the Hubble Ultra Deep Field region. The powerful Constellation-X, a planned mission, is a different type of tool maximized for collection efficiency, not angular resolution. To see the first black holes, and perhaps the first objects to form, we would need something like Generation X, proposed for the next decade.

Some gamma-ray bursts might be explosions of the first generation of stars. The Swift mission, to launch later this year, may provide insight. Piece by piece we are mapping the entire history of the Universe with the ultimate goal of seeing the Big Bang itself, not just its afterglow. We may accomplish this feat by 2025. Then, at long last, we will have arrived. **m**

CHRISTOPHER WANJEK of NASA/SP Systems is enjoying the ride.