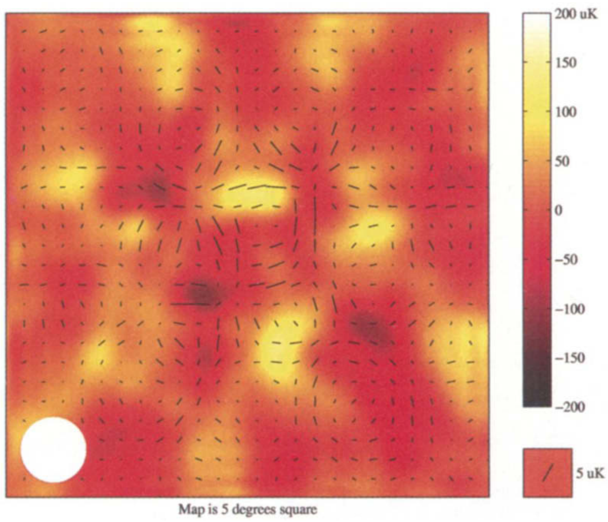
MICROWAVE BACKGROUND

Subtle Signals in Ancient Light Promise New View of Cosmos

CHICAGO, ILLINOIS—A new chapter in the study of the early universe opened last week. At a meeting here,* physicists from the University of Chicago announced the first detection of polarization in the cosmic microwave background (CMB), the light left over from the very early ages of the cosmos. The much-anticipated result is squarely in line with theoretical predictions, a sign that physicists' theories about the makeup and evolution of the universe are on track. "It is a dramatic confirmation of the ideas in the cosmological standard model," says Wayne Hu, a cosmologist at the University of Chicago who did not take part in the work. "If they didn't see it, we couldn't say we know how atoms form. It's as fundamental as that." The achievement also heralds the start of a new approach for deciphering the CMB.

The results came from the Degree Angular Scale Interferometer (DASI), a microwave telescope based near the South Pole. DASI peers into the heavens for light that scattered off the first atoms, which formed when the universe was 400,000 years old. Detected in 1965 by Arno Penzias and Robert Wilson of Bell Labs, the CMB, stretched and attenuated by 14 billion years of travel, looks much the same in all directions except for faint hot and cold spots caused by the sloshing of matter in the early universe. In 2000 and 2001, sensitive microwave telescopes, including DASI, made a splash by producing exquisitely detailed maps of those temperature variations (*Science*, 4 May 2001, p. 823). From those maps, scientists divined the amount of matter and energy in the universe and showed, beyond a reasonable doubt, that the "shape" of spacetime was flat (*Science*, 28 April 2000, p. 595).

Polarization, the "orientation" of the incoming light, adds another dimension to the map of the CMB. "It's going to triple the amount of information that we get from the [CMB]," DASI team member John Kovac, a cosmologist at the University of Chicago, said in a statement released at the meeting. "It's like going from the picture on a black-and-white TV to color."



Glimpsed. DASI telescope (*right*) detected polarization of cosmic radiation (black lines, *above*).

Theorists had long suspected that light from the CMB is polarized. Because of the Doppler effect, atoms hurtling through the early universe would have scattered light differently depending on whether the rays were heading toward or away from the moving atoms. That differential leads to a preferred polarization in the scattered light. The faster a clump of matter is moving, the more pronounced that preference. Because polarization, unlike temperature fluctuation, is not distorted by gravitational kneading as it travels through space, the pattern of polarization in the microwave sky could, in theory, give cosmologists an even sharper picture of the early universe than temperature maps can reveal. But that possibility was just a dream until physicists could detect that polarization, which is only a tenth as strong as even the tiny temperature fluctuations.

The dream is now becoming a reality. "We've detected polarization at a high level of confidence," says John Carlstrom, the leader of the DASI team. The team claims a "five sigma" detection, a confidence level that physicists consider extremely convincing. "They didn't just kind of maybe see it; they really saw it," says Max Tegmark, a cosmologist at the University of Pennsylvania in Philadelphia. "I was very, very psyched." Physicists had feared that the faint signal might be swamped by polarized light from other sources, Tegmark says. "The Achilles' heel of the whole polarization challenge is polarized space junk that could completely hose everything," he says, adding that the lack of noise "bodes really well for the future of the field."

That future promises to be bright indeed. Ever-more-sensitive observations by DASI and its rivals BOOMERANG, CAPMAP, MAXIPOL, and a handful of other telescopes in operation or scheduled to begin observing within the next few years should give physicists an incredibly accurate picture of how the matter in the early universe was moving under the influences of radiation and gravity. That information will likely reveal precisely what the cosmos is made of by revealing the balance of matter and energy in the primordial plasma and also help clarify the laws of physics that set the matter in motion. And another 10-fold improvement in sensitivity, which will be within reach of the Planck satellite, scheduled to be launched in 2007, might even reveal ancient gravitational waves, which would shed light on the very earliest moments of the universe. "We'll be probing the universe at 10^{-30} of a second," says Carlstrom. Although the DASI results are but a first step, cosmologists hope that the polarization of the CMB will contain the universe's baby pictures.

—CHARLES SEIFE

* Cosmo-02, 18–21 September.

CREDITS: (TOP TO BOTTOM) DASI; STEPHANIE ROWATT