University of Sheffield in the U.K. Knapp sees an additional value: Grasslands may serve as "early warning systems" that ecosystems are being altered by a changing climate—long before the trees migrate northward. —JOCELYN KAISER

ASTROPHYSICS

Microwave Telescope Data Ring True

Scientists listening for the faint hiss of radiation left over from the big bang have just gotten an earful. Data from a telescope in Chile designed to hear the cosmic background radiation are providing strong support for theories about how the universe evolved during the first few hundred thousand years after the big bang. The result—which shows a signal that other experiments have missed—is the first from the Cosmic Background Imager (CBI) and the beginning of what scientists say could be a banner year for cosmology.

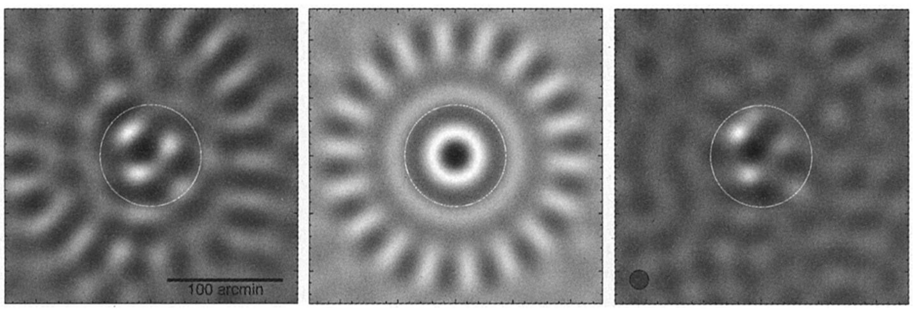
"It's really an exciting time," says Scott Dodelson, a cosmologist at Fermi National Accelerator Laboratory in Batavia, Illinois. The CBI is catching the whispers of radiation born about 300,000 years after the big bang, when the universe was too hot for atoms to form. Light was constantly scattered in the monstrous plasma fireball, which reverberated with echoes of the great explosion. But as the universe cooled, electrons settled down with nuclei to form atoms. The opaque plasma became transparent, and the light that had been scattered and rescattered broke free.

That light, in the form of microwaves, now bombards Earth from all directions, allowing telescopes sensitive to that radiation to take pictures of the 300,000-year-old universe. Most recently, BOOMERANG, a balloon-borne experiment that circled the South Pole, made an exquisite map of the background radiation in a small region of the sky (*Science*, 28 April 2000, p. 595). But excited astronomers were puzzled when the data failed to show an expected pattern in the distribution of the radiation.

The early universe, scientists knew, rang like a bell after the big bang. Pressure waves rattled throughout the cosmos, causing variations in density that now show up as ripples in the amount of background radiation. And just as a bell's sound is made up of a fundamental frequency and a number of weaker higher-frequency overtones, the pressure waves in the universe had a "fundamental" of large-size peaks and dips in density and "overtones" of smaller and weaker peaks. BOOMERANG detected the fundamental's first peak but failed to detect the overtone second peak—as if theorists had predicted a bell but heard a horn instead. The missing second peak challenged observations of the amount of matter in the universe and threatened theories about how atomic nuclei formed. "It's a dilemma. The cosmic background is telling us one thing, but nucleosynthesis is telling us another," says Dodelson.

Now, to cosmologists' relief, the latest observations suggest that the second peak is there after all. "I think the discrepancy is real," says Anthony Readhead, an astronomer at the California Institute of Technology in Pasadena who was on the CBI team. "I don't think it is likely to go away."

Unlike the balloon experiments, which detect incoming radiation by converting it into heat, the CBI uses interferometry—detecting the phase and amplitude of incoming microwaves directly. Because interferometers have only recently become sensitive enough to measure cosmic background radiation, it's too early to say that the missing signal is definitely there, says Jeffrey Peterson, a cosmologist at Carnegie Mellon University in Pittsburgh. "But it takes a little of the sting out of the worries about the second peak."



High fidelity. Raw microwave readings from the Cosmic Background Imager (left), minus instrument noise (center), reveal reverberations left over from the big bang.

However, Peterson says that another aspect of CBI's observations is worth celebrating now as support for an important theory about the acoustics of the early universe. The data show a drop-off in ripple size as the angular scale gets smaller and smaller, indicating that the overtones are weaker and weaker. "It's kind of exciting. It's the first time it's been seen in one experiment," Peterson says. "The acoustic oscillations in the early universe were dying away. It shows we're on the right track, that the acoustic model is right."

Readhead and his colleagues will publish their work in *Astrophysical Journal Letters*. Meanwhile, they are just beginning to analyze the flood of data from CBI. With more BOOMERANG results to come and other cosmic background experiments in sight, astronomers expect that the infant universe will soon snap into sharper-than-ever focus.

—CHARLES SEIFE

SPACE STATION

U.S. Module to Offer Long-Term Lab Space

CAPE CANAVERAL, FLORIDA—Destiny has arrived for U.S. microgravity scientists. After 17 years of planning, dozens of reviews and redesigns, and billions of dollars, the U.S. scientific centerpiece of the international space station is ready to open its hatches for business. Called Destiny, the 8.5-meter-long aluminum vessel is scheduled for launch next month from Kennedy Space Center here. But putting the laboratory module into orbit—a 19 January launch was delayed 3 weeks due to electrical problems—is only the first step in a long and difficult road toward making the space station a scientifically credible venture.

About 120 researchers have already been chosen to conduct experiments in the lab. But the station's long-term value to U.S. commercial and academic researchers—nearly half the current portfolio is from industry—hinges on the ease of operations in space as well as on NASA's ability to fund, streamline, and provide a clear scientific direction for its troubled life and microgravity sciences effort. "This is going to be our Hubble" Space Telescope, says Kathie Olsen, NASA's chief scientist and acting life and microgravity sciences chief. "We need to get the community involved to do the right type of research."

With space station assembly expected to continue until 2006, the lab initially will look more like a construction site than a haven for research. But NASA managers say the module represents a quantum leap in doing science in orbit, with more room, a bigger crew, and far more computer and electrical power than the aging Russian Mir, due for a fiery death in the atmosphere late next month. It's also expected to be open all day, every day, for more than a decade. Once fully outfitted, 13 of the new module's 24 closet-sized racks holding equipment will be devoted to research, and the rest to operational systems. In time, the space station's scientific capacity will be augmented by modules with European and

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