Cosmologists aim to reveal first moments of time

Feb. 16, 2009
Courtesy University of Chicago and World Science staff

Within a decade, a delicate measurement of primordial light might reveal evidence for the popular cosmic inflation theory, which proposes that a random, microscopic density fluctuations in the fabric of space and time spawned the universe.

Such fluctuations would have led to a hot “Big Bang,” as astronomers call the sort of explosion believed to have given birth to the cosmos some 13.7 billion years ago.

Among cosmologists searching for evidence of these events will be John Carlstrom, a University of Chicago cosmologists who operates the South Pole Telescope with scientists from nine institutions.

They plan to put cosmic inflation theory to its most stringent observational test so far by detecting faint “gravity waves”—an exotic phenomenon that Einstein’s general relativity theory predicts cosmic inflation should produce.

“If you detect gravity waves, it tells you a whole lot about inflation for our universe,” Carlstrom said. It also would rule out various competing ideas for its origin. “There are fewer than there used to be, but they don’t predict that you have such an extreme, hot big bang, this quantum fluctuation, to start with,” he said. Nor would they produce gravity waves at detectable levels.

Carlstrom and colleague Scott Dodelson were on panel of cosmologists discussing these and related issues on Feb. 16 at the American Association for the Advancement of Science annual meeting in Chicago. Fellow panelists included Alan Guth of the Massachusetts Institute of Technology. In 1979, Guth proposed the cosmic inflation theory, which predicts the existence of an infinite number of universes. Unfortunately, cosmologists have no way of testing this prediction.

“Since these are separate universes, by definition that means we can never have any contact with them. Nothing that happens there has any impact on us,” said Dodelson, a scientist at Fermi National Accelerator Laboratory and a Professor in Astronomy & Astrophysics at the University of Chicago.

But there is a way to probe the validity of cosmic inflation. The phenomenon would have produced two classes of perturbations, cosmologists say. The first, fluctuations in the density of subatomic particles, happen continuously everywhere; scientists have detected them. Inflation would have instantaneously stretched some of these perturbations into cosmic proportions. “We can calculate what those perturbations should look like, and it turns out they are exactly right to produce the galaxies we see in the universe,” Dodelson said.

The second class of perturbations would be gravity waves—Einsteinian distortions in space and time. Gravity waves also would get promoted to cosmic proportions, perhaps even strong enough for cosmologists to detect them with sensitive telescopes. “We should be able to see them if John’s instruments are sensitive enough,” Dodelson said.

Carlstrom and colleagues are building a special instrument, a polarimeter, as an attachment to the South Pole Telescope, to search for gravity waves. The telescope is built to detect light waves from the microwave to the infrared range.

Cosmologists also use the telescope in their quest to solve the mystery of dark energy. A repulsive force, dark energy pushes the universe apart and overwhelms gravity, the attractive force exerted by all matter. Dark energy is invisible, but astronomers are able to see its influence on clusters of galaxies that formed within the last few billion years.

The South Pole Telescope detects the cosmic microwave background radiation, the afterglow of the “Big Bang.” Cosmologists have mined a fortune of data from the microwave background data, which represent the forceful drums and horns of the cosmic symphony. But now the scientific community has its ears cocked for the tones of a subtler instrument—gravitational waves—that underlay the microwave background.

“We have these key components to our picture of the universe, but we really don’t know what physics produces any of them,” said Dodelson of inflation, dark energy and the equally mysterious dark matter. “The goal of the next decade is to identify the physics.”

Image 1: The South Pole Telescope takes advantage of the clear, dry skies at the National Science Foundation's South Pole Station to study the cosmic back ground radition, the after glow of the big bang. The telescope measures eight meters (26.4 feet) in diameter. (Photo by Jeff McMahon)

Image 2: A simulation (click on image) of distortions in space and time at the subatomic scale, the result of quantum fluctuations occurring continuous throughout the universe. Near the end of the simulation, cosmic inflation begins to stretch space-time to the cosmic proportions of the universe. (Courtesy S. Dodelson, Fermi lab/U. Chicago)