Universe as an Infant: Fatter Than Expected and Kind of Lumpy

A view of the cosmic microwave background collected by the European Space Agency’s Planck satellite. The heat map of the cosmos was imprinted on the sky when the universe was just 380,000 years old.

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Astronomers released the latest and most exquisite baby picture yet of the universe on Thursday, one that showed it to be 80 million to 100 million years older and a little fatter than previously thought, with more matter in it and perhaps ever so slightly lopsided.

Recorded by the European Space Agency’s Planck satellite, the image is a heat map of the cosmos as it appeared only 370,000 years after the Big Bang, showing space speckled with faint spots from which galaxies would grow over billions of years.

The map, the Planck team said in news conferences and in 29 papers posted online Thursday, is in stunning agreement with the general view of the universe that has emerged over the past 20 years, of a cosmos dominated by mysterious dark energy that seems to be pushing space apart and the almost-as-mysterious dark matter that is pulling galaxies together. It also shows a universe that seems to have endured an explosive burp known as inflation, which was the dynamite in the Big Bang.

In a statement issued by the European Space Agency, Jean-Jacques Dordain, its director general, said, “The extraordinary quality of Planck’s portrait of the infant universe allows us to peel back its layers to the very foundations, revealing that our blueprint of the cosmos is far from complete.”

Within the standard cosmological framework, however, the new satellite data underscored the existence of puzzling anomalies that may yet lead theorists back to the drawing board. The universe appears to be slightly lumpier, with
bigger and more hot and cold spots in the northern half of the sky as seen from Earth than toward the south, for example. And there is a large, unexplained cool spot in the northern hemisphere.

Those anomalies had shown up on previous maps by NASA’s Wilkinson Microwave Anisotropy Probe, or WMAP, satellite, but some had argued that they were because of a bad analysis or contamination from the Milky Way.

Now cosmologists will have to take them more seriously, said Max Tegmark, an expert on the early universe at the Massachusetts Institute of Technology who was not part of the Planck team. He described the new results as “very exciting.” It could be, he said, that “the universe is trying to tell us something.”

George Efstathiou, of Cambridge University, one of the leaders of the Planck project, said in the European Space Agency news release: “Our ultimate goal would be to construct a new model that predicts the anomalies and links them together. But these are early days; so far, we don’t know whether this is possible and what type of new physics might be needed. And that’s exciting.”

The Planck satellite was launched in 2009 and has been scanning the sky ever since, recording the faint variations in a haze of radio microwaves that fill the sky.

Microwaves are a form of electromagnetic radiation used in the kitchen for heating leftovers; that they are important for cosmology was discovered by accident back in 1965 by a pair of Bell Labs radio astronomers, Arno Penzias and Robert W. Wilson, who later won the Nobel Prize in Physics. Using balloons, a U-2 spy plane and a series of satellites like the WMAP, astronomers have been teasing out the detailed features of this radiation.

The microwaves detected by the Planck date from 370,000 years after the Big Bang, which is as far back as optical or radio telescopes will ever be able to see, cosmologists say. But the patterns within them date from less than a trillionth of a second after the Big Bang, when the universe is said to have undergone a violent burst of expansion known as inflation that set cosmic history on the course it has followed ever since. Those patterns are Planck’s prize.

Analyzing the relative sizes and frequencies of spots and ripples over the years has allowed astronomers to describe the birth of the universe to a precision that would make the philosophers weep. The new data have allowed astronomers to tweak their model a bit. It now seems the universe is 13.8 billion years old, instead of 13.7 billion, and consists by mass of 4.9 percent ordinary matter like atoms, 27 percent dark matter and 68 percent dark energy.

Marc Kamionkowski, an astrophysicist at Johns Hopkins University who commented on the work at a news teleconference sponsored by NASA, called Planck “cosmology’s human genome project,” saying, “It shows the seeds from which the current universe grew.”

David N. Spergel, a Princeton University cosmologist, described the new results as “beautiful.”

“The standard cosmological model looks even stronger today than yesterday,” he said. “The universe remains simple and strange.”

The biggest surprise here, astronomers said, is that the universe is expanding slightly more slowly than previous measurements had indicated. The Hubble constant, which characterizes the expansion rate, is 67 kilometers per second per megaparsec — in the units astronomers use — according to Planck. Recent ground-based measurements combined with the WMAP data gave a value of 69, offering enough of a discrepancy to make cosmologists rerun their computer simulations of cosmic history.
The fact that astronomers once would go to war over a factor of two in measurements of this parameter shows how cosmology has progressed over the past 20 years. Pressed for a possible explanation for the discrepancy, Martin White, a Planck team member from the University of California, Berkeley, said it represents a mismatch between measurements made of the beginning of time and those made more recently, and that it could mean that dark energy, which is speeding up the expansion of the universe, is more complicated than cosmologists thought. He termed the possibility "pretty radical," adding, "That would be pretty exciting."

The data also offered striking support for the notion of inflation, which has been the backbone of Big Bang theorizing for 30 years. Under the influence of a mysterious force field during the first trillionth of a fraction of a second, what would become the observable universe ballooned by 100 trillion trillion times in size from a subatomic pinprick to a grapefruit in less than a violent eye-blink, so the story first enunciated by Alan Guth of M.I.T. goes.

Submicroscopic quantum fluctuations in this force field are what would produce the hot spots in the cosmic microwaves, which in turn would grow into galaxies. According to Planck's measurements, those fluctuations so far fit the predictions of the simplest model of inflation, invented by Andrei Linde of Stanford, to a T.

Dr. Tegmark of M.I.T. said, "We're homing in on the simplest model."

Cosmologists still do not know what might have caused inflation, but the recent discovery of the Higgs boson has provided evidence that the kinds of fields that can provoke such behavior really exist.

Dr. Tegmark and others said that another clue to the nature of inflation could come from the anomalies in the microwave data — the lopsided bumpiness, for example — that tend to happen on the largest scales in the universe. By the logic of quantum cosmology, they were the first patterns to be laid down on the emerging cosmos; that is to say, when inflation was just starting.

He compared it to walking in on a fight. If the fight has been going on for a while, he said, it is impossible to tell who started it or who was hurt first. But if you come in only a few seconds after it started, you have a better chance of figuring out who did what to whom.

“It may be,” he said, “we’re coming in early to the cosmic brawl.”

This article has been revised to reflect the following correction:

Correction: March 21, 2013

An earlier version of this article misstated the percent of the universe by mass that is made up of dark energy. It is 68 percent, not 71.

A version of this article appeared in print on March 22, 2013, on page A10 of the New York edition with the headline:
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