Cosmic inflation: Dust finally settles on BICEP2 results

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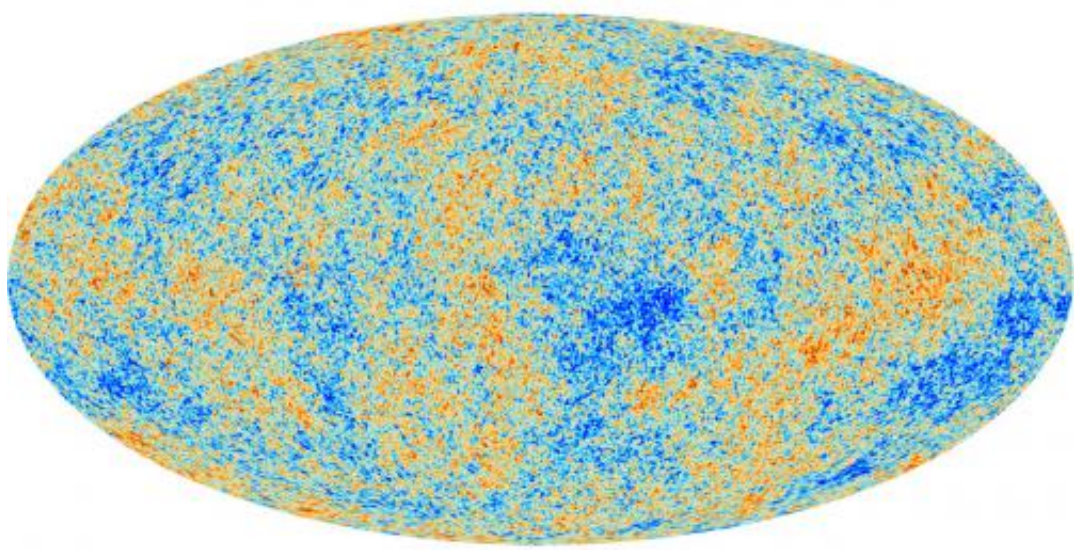

The anisotropies of the Cosmic Microwave Background (CMB) as observed by Planck. The CMB is a snapshot of the oldest light in our Universe, imprinted on the sky when the Universe was just 380 000 years old. It shows tiny temperature fluctuations that correspond to regions of slightly different densities, representing the seeds of all future structure: the stars and galaxies of today. The highest resolution version of this image [12 572 px × 6286 px] is available upon request. Please make inquiries using the "Contact Us" link in the left-hand menu. Credit: ESA, Planck Collaboration

Reports of evidence of cosmic inflation may have been, well, overblown.

When the BICEP2 team announced last year that they had found signs of cosmic inflation, the universe's powerful growth spurt that had been predicted but that had never been directly detected, it was seen as a potentially major breakthrough in cosmology. But now, a joint team that includes the BICEP2 researchers has found that there is no clear evidence of the primordial gravitational waves that signaled this enormous growth spurt, and that much of the signal was clearly caused by dust.

"I think the conclusion is that the BICEP2 team misinterpreted their results," said David Spergel, a Princeton University cosmologist who was not involved in the work and who wrote a paper last year arguing that the strange signal was due to dust. "They effectively with this paper have withdrawn their claim of detection."

The findings, submitted to the journal *Physical Review Letters*, leave the search for primordial gravitational waves wide open.

"It leaves us on the journey. We haven't found the signal that we hoped to see," Spergel said. "That doesn't mean it's not there; doesn't mean it is there. It leaves us with work to do."

The BICEP2 team (short for Background Imaging of Cosmic Extragalactic Polarization) used a small telescope near the South Pole as well as data from the Keck Array (also in Antarctica) to search for an incredibly weak signal coming from the heavens.

In March, the BICEP2 collaboration announced that it had found evidence of cosmic inflation - a violent expansion of the universe that

occurred a tiny fraction of a second after the Big Bang, 13.8 billion years ago. Looking at a patch of sky, they had found what they believed were telltale signals in the patterns of light filling the cosmic microwave background, which is a low-level "afterglow" from the birth of the universe that permeates the cosmos.

These swirling patterns of polarized light, called B-modes, were thought to be the faint imprint left over in the cosmic microwave background as gravitational waves triggered by cosmic inflation sent ripples through space-time.

But the results quickly drew scrutiny from the scientific community, many of whose members questioned the BICEP2 team's analysis.

That's in part because other phenomena in the universe can also cause B-modes, particularly the galactic dust that permeates our view of the cosmos. The BICEP2 team looked at light emanating from the cosmos at 150 gigahertz, and had found very low levels of dust. The signal, then, was probably due to primordial gravitational waves, they surmised.

But data from the European Space Agency's Planck mission suggest otherwise. The Planck mission is mapping the dust across the entire sky, looking at different bands of light. They looked in nine different frequencies, seven of which had detectors that were sensitive to polarization, but the key frequency was the highest: the 353-gigahertz band, where the dust shines more brightly than at other wavelengths.

The Planck team announced in September that they'd found polarized light in significant amounts across the sky - perhaps high enough to account for most of the BICEP2 signal.

And now, after teaming up, the Planck and BICEP2 scientists have released a paper titled "A Joint Analysis of BICEP2/Keck Array and

Planck Data," which finds there's no compelling evidence that the polarization signal described in March was actually due to primordial gravitational waves.

"I think that we were more optimistic that this test would be stronger than it turns out to be," said California Institute of Technology experimental cosmologist James Bock, one of the lead scientists for BICEP2 - although he added that there was enough noise to limit the dust measurement somewhat.

"The dust is at least 40 percent of the signal," he said. "Could be all of it, but it's at least 40 percent. So we can't conclude the whole signal is dust and we can't conclude there's no gravitational waves."

The researchers did find another source of B-mode polarization that originated in the universe's early days, a signal discovered in 2013. These swirls in the background light are caused by the massive structures, such as galaxy clusters, that make up the cosmic web that gives the universe its structure, and whose gravity can bend the path of the light coming from the cosmic microwave background.

This doesn't mean that direct evidence of cosmic inflation - this formative period in the universe's history - will never be found, Bock said. But if they don't find a signal in the data at some point, this may prove just as interesting, because it could mean that longstanding theories about cosmic inflation may have to be rewritten.

"Part of the attraction of doing this is whether we detect a signal or not, we'll learn more about the process of inflation in the early universe," Bock said. "If we don't see a signal down to a certain level, it means the early models of inflation that Alan Guth and others (came up with) are not likely to be the right explanation. So that's an interesting regime to be in."

One way or another, with many different experiments probing these questions, the answers are likely just on the horizon, Bock said, perhaps within the next couple of years.

More information: "A Joint Analysis of BICEP2/Keck Array and Planck Data" by the BICEP2/Keck and Planck collaboration has been submitted to the journal *Physical Review Letters*.

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