

## COSMOLOGY

# Big Bang finding challenged

*Signal of gravitational waves was too weak to be significant, studies suggest.*

BY RON COWEN

The astronomers who earlier this year announced that they had evidence of primordial gravitational waves jumped the gun, two independent analyses suggest.

The papers, published on the arXiv preprint repository, propose that the original analysis did not properly account for the confounding effects of galactic dust. Although further observations may yet confirm the findings, independent researchers now say they no longer think that the original data constituted significant evidence.

“Based on what we know right now, we have no evidence for or against gravitational waves,” says Uroš Seljak, a cosmologist at the University of California, Berkeley, and co-author of one of the latest studies<sup>1</sup>.

Astronomers using the BICEP2 radio telescope at the South Pole announced in March that they had found a faint twisting pattern in the polarization of the cosmic microwave background (CMB), the radiation left over from the Big Bang. This pattern, they said, was evidence for primordial gravitational waves — ripples in the fabric of space-time generated in the Universe’s first moments. The findings were widely hailed as confirmation of the theory of cosmic inflation, which holds that the cosmos ballooned in size during the first fraction of a second after the Big Bang.

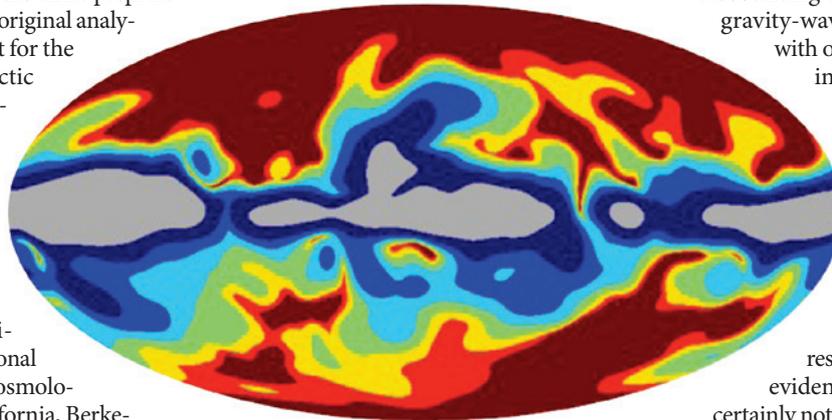
But the new analyses suggest that the twisting patterns in the CMB polarization could just as easily be accounted for by dust in the Milky Way<sup>1,2</sup>.

The papers follow a presentation three weeks ago by Raphael Flauger, a theoretical physicist at New York University and the Institute for Advanced Study in Princeton, who re-examined a map of galactic dust used by BICEP2. Flauger concluded that the BICEP2 researchers had probably underestimated the fraction of polarization caused by dust in the map, which was compiled from data from the European Space Agency’s Planck spacecraft. Flauger says that when the dust is fully accounted for, the signal that can be attributed to gravitational waves either vanishes or is greatly diminished.

“I had thought that the [BICEP2] result was very secure,” said Alan Guth, the cosmologist who first proposed the inflation concept in 1980, after learning about Flauger’s talk.

“Now the situation has changed,” added Guth, who works at the Massachusetts Institute of Technology in Cambridge.

The BICEP2 researchers have argued that the Planck map figured in only one of the six models that they used to examine the role of



Cross-checks of gravitational-wave results used this galactic-dust map from the Planck satellite.

dust. But in a paper<sup>2</sup> posted to the arXiv server on 28 May, Flauger and his co-authors David Spergel and Colin Hill, both of Princeton University in New Jersey, say that the five other models are based on a low estimate — between 3.5% and 5% — of the fraction of total polarization caused by galactic dust. Extrapolation from a more detailed map, released last month by the Planck team, suggests that the fraction is closer to 8–15%, Spergel explains.

With those updated numbers, he says, “there’s no evidence for the detection of gravitational waves”. But a final determination cannot be made until a more precise dust map, expected to be released by the Planck team in October, is available, he adds.

In the other analysis<sup>1</sup>, Seljak and Michael Mortonson, a cosmologist also at the University of California, Berkeley, re-examined BICEP2 data on how the polarization signal varies with the frequency of the microwaves it detects. The BICEP2 team had checked its results against data recorded at lower frequency by an older telescope, BICEP1. They found that the intensity of polarization did not change from one frequency to the other in the way expected if it were caused by dust, and concluded that the data favoured gravitational waves over dust by an 11-to-1 margin.

But Seljak and Mortonson say that the BICEP2 analysis did not exclude data on small spatial scales, or fractions of degrees of the sky.

That is a problem, Seljak says, because on these small scales, gravitational lensing — in which the path of light bends around massive objects — exactly mimics the twisting polarization pattern that gravitational waves imprint on larger spatial scales.

Accounting for lensing, “the primordial gravity-wave signal is preferred to dust with odds of less than two to one — in other words, not significant odds at all,” says Seljak.

BICEP2 co-leader James Bock, a physicist at the California Institute of Technology in Pasadena, says that although his group’s main paper “has been revised based on many referee comments and resubmitted” for publication, the evidence for gravitational waves “is certainly not being retracted”. The BICEP2 results “are basically unchanged”, he says.

Further observations may yet see the cosmic ripples emerge from the dust. It is possible that forthcoming data from several observatories — including the Keck Array, a telescope at the South Pole built by the BICEP2 team — and the Planck team’s full-sky map of CMB polarization will confirm that a signal is there, although perhaps not as strong as first suggested. ■

1. Mortonson, M. M. & Seljak, U. Preprint at <http://arxiv.org/abs/1405.5857> (2014).
2. Flauger, R., Hill, J. C. & Spergel, D. N. Preprint at <http://arxiv.org/abs/1405.7351> (2014).

## CORRECTIONS

The News story ‘Jelly genome mystery’ (*Nature* **509**, 411; 2014) wrongly stated that ctenophores might be the closest living relatives of the first animals. It should have said that ctenophores may represent the earliest lineage to split off from the common ancestor of all animals. The News story ‘US Arctic research ship ready to cast off’ (*Nature* **509**, 542–543; 2014) incorrectly stated that a deck on the vessel able to accommodate large equipment is at the bow — it is at the stern. The News Feature ‘Complexity on the horizon’ (*Nature* **509**, 552–553; 2014) inadvertently underplayed the role of Daniel Harlow in bringing computational complexity to fundamental physics — he worked with Patrick Hayden from the start of their project.