their energies on the bed in a much more random fashion.

This may sound logical, but it is precisely the opposite of the behaviour seen in thermodynamic systems: ice releases energy into a more disordered state when it melts, and crystallizes into a more ordered state when it re-freezes. Glassy systems, often associated with grains, also typically gain entropy when they melt or sublimate. Grains, however, apparently focus energy when they unjam, and disperse it when they jam.

Moreover, Banigan *et al.* found that the instabilities of particles grow in advance of slip[1]. These results contribute to a growing body of recent work hinting that slip in granular beds may be preceded by identifiable effects, including a growth in local disorder[6] and an increase in the rate of breaking of intergrain bonds[7]. Although it may be too much to hope that these tantalizing ideas could one day lead to improved prediction of slip events, the application of tools from diverse disciplines is a welcome development, and the new findings should provoke renewed interest in the many perplexing behaviours to which simple grains are prone[8]. ❒

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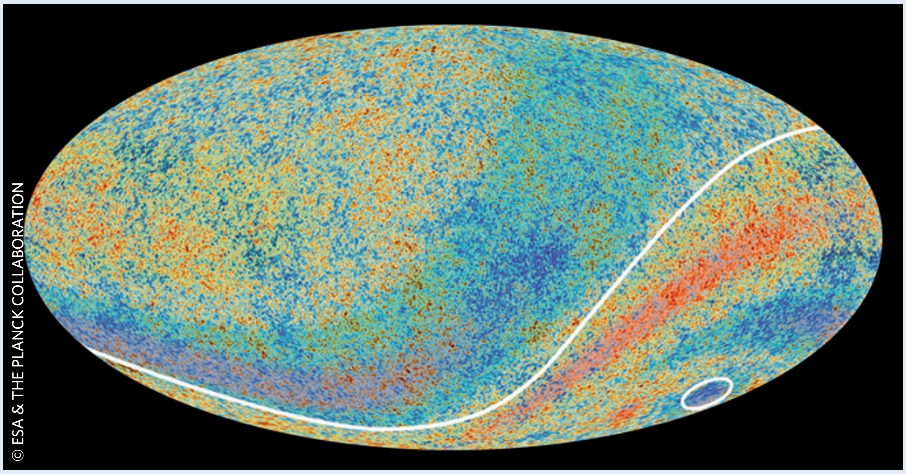
COSMOLOGY

Across the Universe

Cosmology has come a long way. The existence of the cosmic microwave background (CMB) was first predicted in 1948 by Ralph Alpher and Robert Herman, its temperature estimated to be about 5 K. The idea, however, didn't gain much currency among scientists until the early 1960s. Then, in 1964, Arno Penzias and Robert Wilson saw it — their horn antenna at Bell Telephone Laboratories in New Jersey was blighted by an unexplained excess temperature of about 3 K. This was the echo of the Big Bang — the ripple of photons released across a universe less than 400,000 years old, as electrons and protons became bound together into hydrogen atoms.

Satellite-borne detectors have since revealed the exquisite black-body spectrum of the CMB, with a temperature of 2.73 K. In 1992, NASA's Cosmic Background Explorer (COBE) reported the long-sought anisotropy in the CMB: tiny fluctuations in its temperature across the sky that indicate density inhomogeneities in the early Universe, from which the structure of the present Universe grew. The gentle variations in colour across COBE's sky map became a telling pattern of blobs in the more precise version produced by NASA's Wilkinson Microwave Anisotropy Probe (WMAP), which was launched in 2001. And now the map has evolved again, into the intricately speckled sky map pictured here, recorded by ESA's Planck satellite.

The precision of the data from Planck is breath-taking, and a ringing endorsement of the standard cosmological model. The data also indicate that the Hubble constant is lower than had been thought, and the Universe slightly older; the relative proportions of matter, dark matter and dark energy have been revised; and there is no evidence of any additional neutrino species beyond the three already known — no sign of a sterile neutrino. There is more to come: in 2014, the Planck collaboration will release more data, plus its data on the polarization of the CMB, which will be crucial in understanding gravitational waves and the inflationary history of the Universe. That there was a period of exponential expansion — of single-field, slow-roll inflation — is already strongly signalled.



There are two mysteries, however, that have only deepened with the results from Planck. Data from WMAP had suggested that there is an asymmetry in the CMB signal between the two opposite hemispheres of the sky, stronger on average in one hemisphere than the other. That asymmetry is confirmed, and very much reinforced, by the Planck data; unexplained, it has been dubbed 'the axis of evil' (and is indicated by the white line on this Planck map). Also confirmed is the presence of a 'cold spot' (white circle), a region of lower temperature that extends across a greater area of sky than expected. Suggestions for what is causing it include the existence of a 'supervoid'; a 'bruise' left by the collision of this Universe with another; or even the imprint of the quantum entanglement, before inflation, of this Universe with a parallel one.

ALISON WRIGHT