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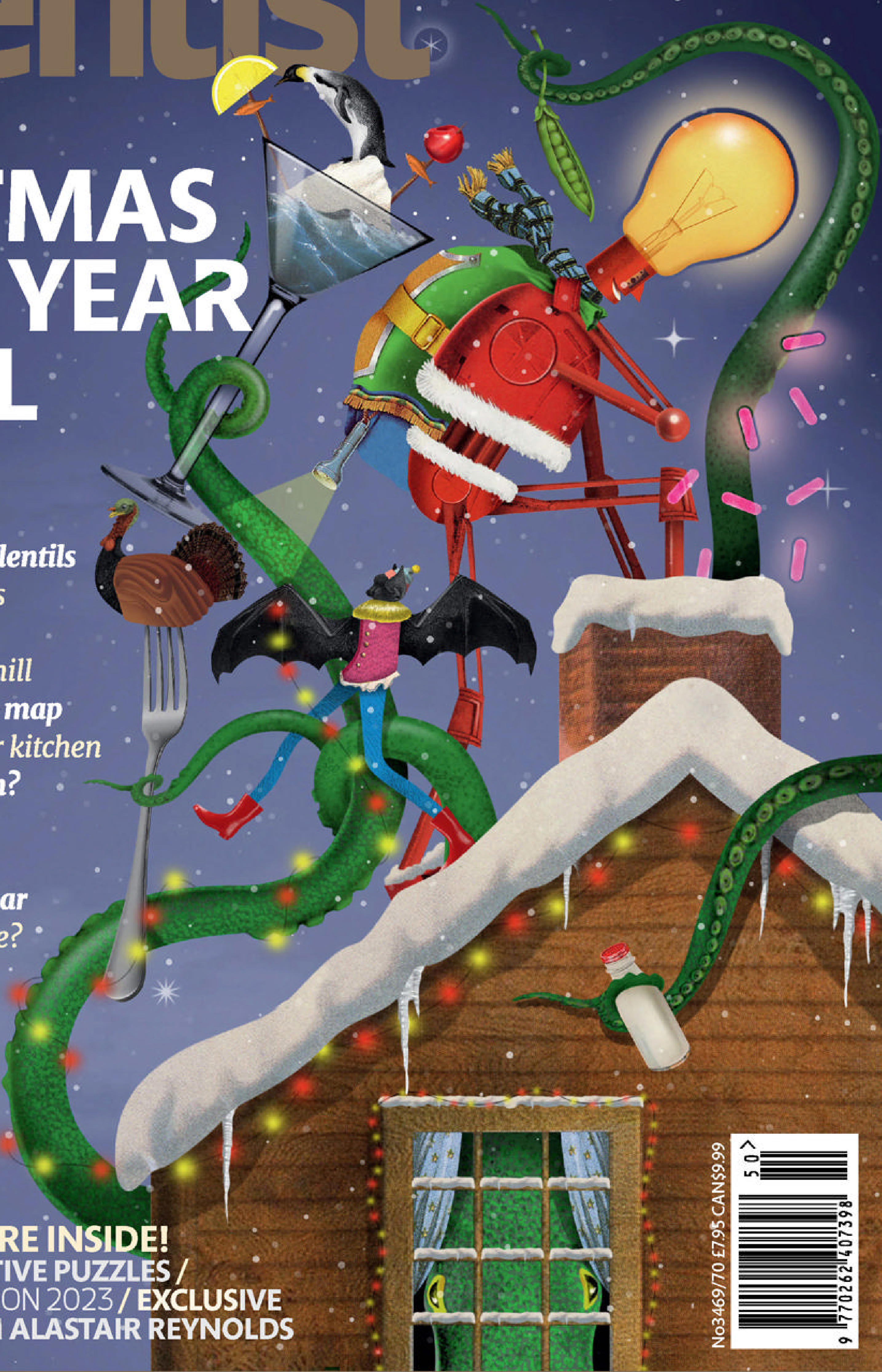

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Astronomy

A problem with cosmic clumps

Material in the nearby universe seems less clustered than we think it should be

Leah Crane

WE DON'T know how clumpy the universe is. A survey of more than 25 million galaxies has found a discrepancy between the two main ways to measure how matter is clustered, suggesting that there is something wrong with the widely accepted standard model of cosmology – our best understanding of the universe.

The work looked at three years of data from the Hyper Suprime-Cam (HSC) programme, based at the Subaru telescope in Japan. Crucial to the finding was an effect called weak gravitational lensing, which occurs when light from other galaxies is stretched by the gravity of matter between those galaxies and our telescopes. This warps the apparent shapes of such galaxies and, by observing lots of them, researchers in the HSC collaboration could make inferences about the structure of matter in the universe.

What they found was an issue with a number called the S8 parameter, which measures the lumpiness of the distribution of matter in the cosmos.

There are two main ways to calculate S8. The first is by observing galaxies in the relatively nearby universe, which is what the HSC team did. The second is by observing fluctuations in the cosmic microwave background (CMB) – ancient light left over from the big bang – and then using the standard model of cosmology to simulate what the matter distribution should look like now. This was the approach taken by the Planck space observatory in earlier studies.

The CMB method results in an S8 value of about 0.83, but the HSC analysis puts it at about 0.77, meaning matter is less clustered (*Physical Review D*, in press). It is a small difference, but it could have big consequences in terms of our understanding of the universe.

NASA, ESA, AND B. SUNNQUIST AND J. MACK (STSCI)

Abell 370 is a distant collection of several hundred galaxies

"We've already seen hints of a discrepancy in other lensing experiments, and this confirms it," says Roohi Dalal at Princeton University, a member of the HSC collaboration. "We're now at a stage where we really have to understand what's causing those low values."

Wiggle room

There are three main collaborations measuring S8 via gravitational microlensing, and all three have found similar results. That makes the latest finding more robust, but it isn't set in stone yet, says Bhuvnesh Jain at the University of Pennsylvania, who is part of one of the other collaborations, the Dark Energy Survey. There could be other explanations for the findings, such as a common flaw in these surveys.

"It's not completely ruled out that we're all making a related mistake," he says. "There's a little bit of overlap in the calibrating and the methodology, so that's my biggest worry."

The question of whether tension between the gravitational lensing and CMB methods of measuring S8 has a physical cause or is simply due to some statistical error should be answered in the coming years, though. Several new telescopes, including the Vera C. Rubin Observatory in Chile, are due to start working soon and will provide data on enormous samples of galaxies, with 10 times the resolution of any of the current gravitational microlensing experiments.

"This [HSC] data is extremely important because it is the most similar to what we'll get from the Vera C. Rubin survey," says Michael Troxel at Duke University in North Carolina, also part of the Dark Energy Survey collaboration. "If there really is something there to find, we will find it with these next surveys, and this dataset is really the most important one to prepare for those new calibrations."

25m

Number of galaxies surveyed to measure the S8 parameter

If the S8 measurements from HSC and the other gravitational microlensing tests are correct, it means that we have some sort of fundamental misunderstanding of the properties of the universe, but it isn't yet clear where that mix-up could lie.

"Maybe there's slightly less of some matter species or a bit more, or our understanding of the dynamics of dark matter clustering is a little bit incorrect," says Troxel. Weak gravitational lensing is particularly tied to understanding the distribution of dark matter because the only way we can locate such matter is by observing its gravitational effects.

So-called dark energy could also be a factor. "If our understanding of dark energy as a cosmological constant isn't right or there's some small time evolution component to the properties of dark energy, that would explain it," says Troxel.

The problem could even be something a little less exotic, says Dalal. "For example, we don't know how things like jets from supermassive black holes work, so it's possible that our models don't account for the full range of possibilities, and if things like those outflows work differently, that could change our expected values of S8," she says.

Once these results are checked by the next generation of huge telescopes, we can start getting to work on tweaking our understanding of cosmology in an effort to resolve the S8 tension – without breaking anything else. ■