New Scientist

AMAZONIAN MICROBIOMES
What the Yanomami people can teach the world about gut health

CLEAN YOUR BRAIN
How intense neural activity may benefit you

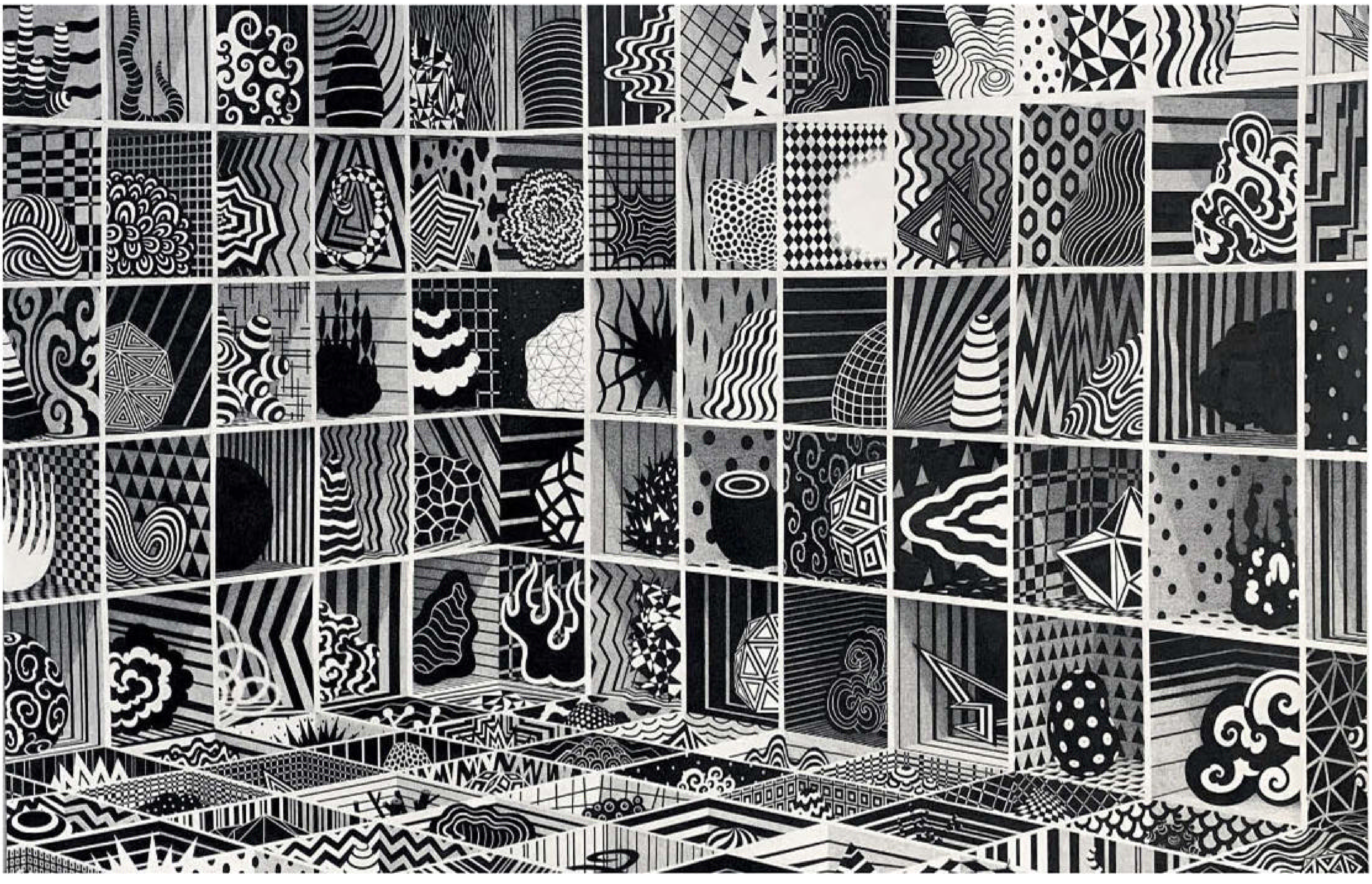
ROAD TO NET ZERO
Will the UK's big climate bets pay off?

WEEKLY 8 April 2023

SPECIAL ISSUE

A FIELD GUIDE TO THE QUANTUM WORLD

Everything you need to know about the particles and phenomena that create reality



PLUS WHY DINOSAURS HAD LIPS / ORIGAMI GLASS / THE JOY OF INSECTS / **RECORD SOLAR TORNADO** / **EUROPE'S FIRST WILD RIVER NATIONAL PARK** / SOLVING STEPHEN HAWKING'S BLACK HOLE PARADOX

No3433 £6.95 CAN$9.99

Astrophysics

Information can survive a black hole

A decades-old paradox uncovered by Stephen Hawking may be solved

Leah Crane

BLACK holes have an information problem. According to the laws of quantum mechanics, information about the state of a closed system can't be destroyed, but black holes seem to obliterate it. Researchers have been trying for decades to solve this so-called black hole information paradox, and now one team claims to have finally figured it out.

The paradox was born in the 1970s when Stephen Hawking calculated that black holes should slowly evaporate by emitting random particles in what is now called Hawking radiation. This suggests that any information-containing matter that falls into a black hole would be destroyed as it eventually shrinks to nothing. But the laws of quantum mechanics require that if you know the state of any closed system at one time, you should be able to work out its state forwards or backwards in time. If Hawking radiation is indeed random, that becomes impossible.

"We have redone the calculation that Hawking did in the 1970s, but we have taken into account quantum gravity," says Xavier Calmet at the University of Sussex in the UK. "The black hole information paradox is solved now, and we understand the physics of it."

In earlier work, he and his team found that when they applied quantum mechanical corrections to calculations of stars evolving into black holes, the black holes' gravitational fields would preserve information about what fell in.

An artist's impression of the black hole in the heart of spiral galaxy NGC 1365

NASA/JPL-CALTECH

Now, they say they have worked out what happens to that information as the black hole evaporates.

This is difficult to solve because of the way the leaking information is distributed. "It comes out again so slowly, and in such small pieces, that you have to dig really deep into the theory" to figure out how the information that fell in relates to what is coming out, says Neil Lambert at King's College London.

Calmet and his team calculated that the gravitational field of a black hole should slightly modify the energy spectrum of Hawking radiation that emerges. "It's a tiny effect, but it means that the spectrum contains information," he says. Any order in the spectrum of Hawking radiation could preserve information (*Physics Letters B*, doi.org/j4qz).

However, not everyone is satisfied yet. "This doesn't fix the problem," says Daniel Harlow at the Massachusetts Institute of Technology. Objections largely boil down to the idea that, ironically, this idea doesn't have enough information about how exactly the information is preserved, particularly when the black hole evaporates completely. "I don't think it's precise enough," says Lambert.

Testing this work will be difficult because Hawking radiation is such a minuscule effect. "Practically, honestly, it's not measurable – we've never seen Hawking radiation from a real black hole," says Calmet. "But there are ways to build analogues to black holes where you can model Hawking radiation." Perhaps these analogues will provide resolution, he says.

Health

Oxygen-sucking battery rids mice of breast cancer

A BATTERY that consumes oxygen and runs on salt water has helped to shrink or eliminate cancer tumours in mice in two weeks.

As most tumours grow, they use up oxygen from surrounding, non-cancerous tissues, making the tumours' cells oxygen-free, or hypoxic. One drug class, hypoxia-activated prodrugs (HAPs), seeks to exploit this trait by only killing hypoxic cells, so healthy cells are less affected. No HAPs are approved for clinical use due to limited evidence of their effectiveness.

Now, Fan Zhang at Fudan University in Shanghai, China, and his colleagues have developed a self-charging, implanted battery that runs off salt water injected around it, causing the battery to produce very low voltage electricity and to consume oxygen. By creating a hypoxic environment, the battery should optimise the HAPs' action.

Zhang and his team induced breast cancer in 25 mice. They then implanted the battery into five of the mice's armpits and gave them HAPs. The other mice either received no treatment, HAPs only, an implanted battery that didn't work or just the working battery, which runs for up to 500 hours in mice.

Fourteen days later, the tumours had shrunk by an average of 90 per cent across the five mice given the battery and HAPs, and they vanished completely in four of these mice (*Science Advances*, doi.org/j4wf). The tumours remained the same size or grew in the other mice.

"After 14 days, the tumours had vanished completely in four of the five treated mice"

While the battery caused no adverse health concerns in the mice, the safety bar is set higher for people, so further research is needed to ensure the battery is compatible with human tissue, says Zhang.

Randall Johnson at the University of Cambridge says that inducing hypoxia in a tumour can increase the risk that the cancer will spread. While this didn't appear to occur in these mice, the costs and benefits of the battery's use in people needs to be assessed before any human treatment, he says.

Alex Wilkins