New Scientist

IS THE DELTA VARIANT WORSE FOR CHILDREN?

LEVITATING OBJECTS WITH SOUND

SECRETS OF ANCIENT DENTAL PLAQUE

NEW QUANTUM BLACK HOLE MYSTERY

WEEKLY September 18-24, 2021

GENERATION COVID

How the pandemic will shape the future of our society

No3352 US$6.99 CAN$9.99

PLUS WHEN ORCAS ATTACK / EL SALVADOR ADOPTS BITCOIN / **FROG NEST FOAM** / EMAIL ENCRYPTION / **SHIFTING JET STREAM**

Science and technology news **www.newscientist.com**

Astrophysics

Black holes just got weirder thanks to quantum pressure

Leah Crane

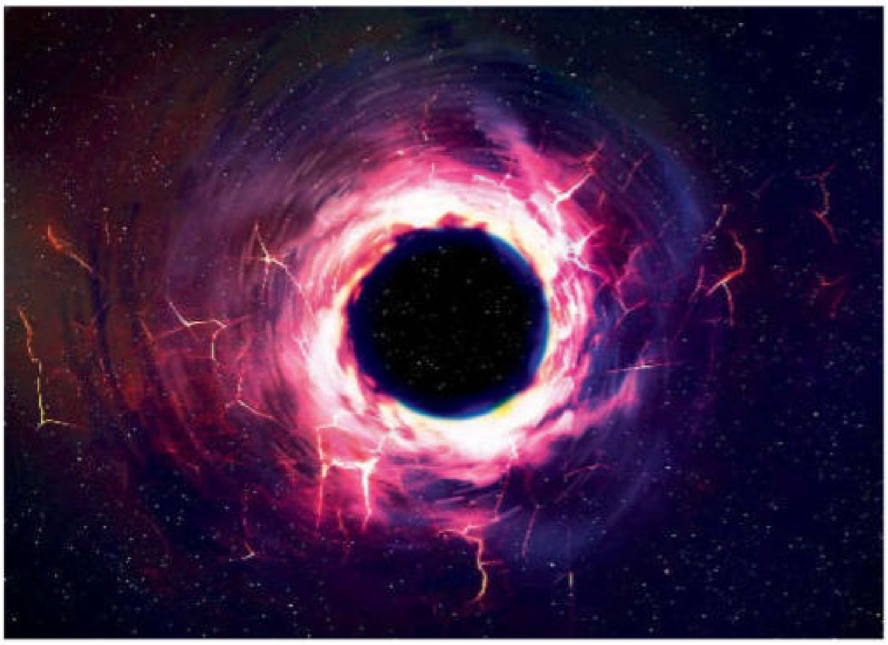
BLACK holes may have their own exotic version of pressure that is different from the sort found everywhere else in the universe, a finding that has surprised physicists.

The question of how quantum mechanics and gravity fit together is one of the biggest mysteries in modern physics, and the edge of a black hole is one of the few regions with conditions extreme enough for the effects of both to be simultaneously relevant. Xavier Calmet and Folkert Kuipers at the University of Sussex in the UK used a framework called quantum field theory to explore what happens when quantum mechanics and gravity meet at the edge of a black hole.

They calculated how tiny quantum fluctuations would create effects not accounted for by our standard equations of gravity. These calculations revealed a surprising variable, which seems to suggest that fluctuations of quantum particles at the edge of a black hole should give the black hole pressure (*Physical Review D*, doi.org/gvnm).

"It was fully unexpected," says Calmet. When black holes were first hypothesised, physicists thought that they should be extremely simple. Later work by Stephen Hawking and others showed that they do emit particles in a process now known as Hawking radiation, which means that they must have a temperature. That in itself was a surprise. Now, the addition of pressure means that black holes are even more complicated, says Calmet.

However, the team hasn't yet figured out what this pressure might mean in a physical sense. The everyday concept of pressure involves molecules pushing against an object and bouncing off it – but the edge, or event horizon, of a black hole is nearly empty.



VADIM SADOVSKI/SHUTTERSTOCK

Artist's impression of bright matter at a black hole's edge

"The source of the pressure here has to be 100 per cent purely quantum fluctuations," says Stephen Hsu at Michigan State University. Quantum fluctuations create virtual particles, which could, in theory, drive the pressure. "It's not the sort of pressure that we're used to," he says.

"The black hole's pressure is negative, so it should cause the black hole to shrink over time"

If you imagine a black hole's event horizon like a balloon, the pressure isn't coming from the interior or exterior to shrink or expand the balloon, it is coming from within the balloon's material itself.

"One can imagine the horizon as a quite peculiar surface, and the pressure will therefore push it inward (if negative) or outward (if positive), which correspond to a reduction or growth of the black hole mass, respectively," says Roberto Casadio at the University of Bologna in Italy.

The researchers found that the pressure was negative, so it should cause a black hole to shrink over time. This is consistent with other work that suggests black holes get smaller as they undergo Hawking radiation. The two phenomena might be connected, but right now this is unclear.

It may take a long time to figure out exactly where this pressure comes from and what its consequences are for our understanding of black holes, says Hsu. But because it comes from quantum fluctuations, learning more about it could be a step towards understanding quantum gravity.

"Any new feature we discover about black holes on the quantum level can give us pointers on how to merge gravity and quantum mechanics, and what features this underlying theory must have," says Calmet. ▮

Marine biology

Sea fireflies adapted threatening glow to attract mates

Jake Buehler

ROUGHLY half of all species of ostracods – bean-shaped crustaceans about the size of a sesame seed – can eject clouds of dazzling blue mucus to startle would-be predators. But in one group of these "sea fireflies" that lives in the Caribbean Sea, males can use the mucus to create glowing patterns to attract mates.

Todd Oakley at the University of California, Santa Barbara, and his colleagues analysed RNA from 45 species of bioluminescent ostracods from around the world, then built an evolutionary tree. This showed how the species were interrelated, and with the help of fossils, it was possible to estimate how long ago the lineages diverged. The team found that sea fireflies got their glow roughly 267 million years ago, well before the first dinosaurs.

The study confirms that ostracods co-opted their defensive glow charges for reproductive ends an estimated 213 million years ago when they split off from their defensively luminous relatives (bioRxiv, doi.org/gvrr).

"We were surprised to find that [the transition] was quite a bit older than we expected," says Oakley. The Caribbean Sea didn't fully form until a few million years ago, suggesting that the sea fireflies that use bioluminescence to attract others may have got their start somewhere else. ▮

A female ostracod (*Photeros annecohenae*) releasing bioluminescence

ELLIOT LOWNDES