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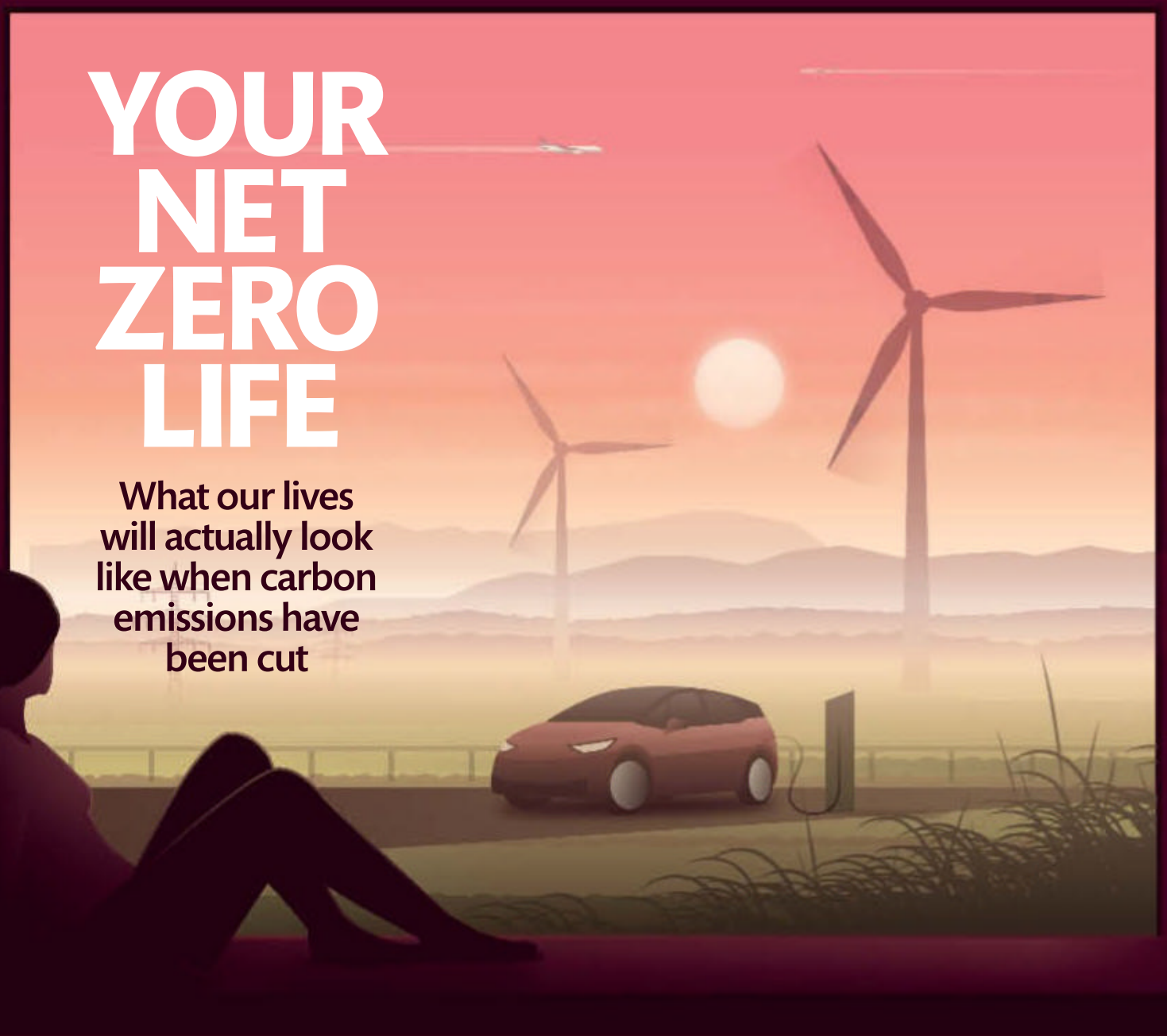

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Cosmology

Waves in space-time could let us see if gravity is quantum

Leah Crane

WE MAY finally have a way to detect the quantum nature of gravity.

The question of how gravity and quantum mechanics fit together has been one of the biggest problems in physics for decades. The way that quantum fluctuations affect gravitational waves – ripples in space-time caused by the movements of massive objects – may give physicists a way to solve it.

Gravity is the one realm of physics that doesn't mesh with a quantum mechanical understanding of the universe. "Our fundamental physical theory is currently incoherent: it is made up of two parts that do not fit," says Carlo Rovelli at Aix-Marseille University in France, who wasn't involved in this work. "To have a coherent world picture we need to combine the two halves."

There has been a lot of theoretical work on this problem, but observations and experiments have yet to make a dent in it. This is mainly because the energy levels at which quantum effects on gravity's behaviour would be apparent are extraordinarily high. One place we find those high energy levels are in astronomical events that produce gravitational waves.

Waves produced by quantum fields, such as light, are by nature both waves and particles. So, if gravitational fields are indeed quantum fields, then gravitational waves should also behave as particles. Those hypothetical particles are called gravitons.

Now, Maulik Parikh at Arizona State University and his colleagues have calculated that the existence of gravitons could create jitters in gravitational wave signals. They found that these could, theoretically, be detected with current gravitational wave observatories.

GIROSCIENCE/ALAMY

Gravitational waves may reveal particles called gravitons

"Maybe the quantum nature of gravity is not so out of reach, and maybe there is an experimental signature of it," says Parikh. "Our prediction is that there's a kind of noise, a graininess, to gravity – and the features of that noise depend on the quantum state of the gravitational field."

"Our fundamental physical theory is incoherent: it is made of two parts that do not fit"

It could be distinguishable from other sources of noise, such as a truck driving past a detector, by the fact that it is likely to manifest as exactly the same fluctuations in the signal at multiple detectors simultaneously (*Physical Review Letters*, doi.org/gsvv).

Observing this noise would be proof that gravity is a quantum force. "We have all reasons to believe that this is the case," says Rovelli. "But in science we want hard empirical tests, not just 'reasons to believe'."

Parikh and his colleagues are now modelling what quantum noise would look like in real-life gravitational wave detections from astronomical events, such as merging black holes or neutron stars, so that we know what to look for.

Finding this signal and proving that gravity is a quantum phenomenon would be a major step towards unifying gravity and quantum mechanics.

Because gravity is a feature of all space-time and quantum mechanics describes matter, this would bring us closer to a self-consistent theory of everything in physics.

"The whole story of gravity is actually the story of space and time," says Parikh. "In a theory of everything, we would expect space and time and matter to be one in a sense, and observing this would be a step towards proving that." ▮

Drugs

US opioid use spiked in the early months of the pandemic

Chris Stokel-Walker

USE of prescription opioids skyrocketed in parts of the US during the early stages of the coronavirus pandemic, while some illicit drug use decreased, according to an analysis of wastewater.

Bikram Subedi and his colleagues at Murray State University in Kentucky analysed wastewater from two communities in western Kentucky and northern Tennessee between March and July 2020.

"Wastewater has many different types of biomarkers that tell us a lot about what's going on in our community," says Subedi. "It's an almost near-real-time approach."

The samples were analysed for levels of 10 illegal drugs and 19 prescription drugs that are commonly abused. Between March and July, levels of the opioid-based painkiller hydrocodone in the wastewater increased by 72 per cent. Levels of prescription antidepressants rose between 7 and 40 per cent, depending on the drug, while anti-anxiety drugs like temazepam and alprazolam increased by nearly 30 per cent.

By comparison, the levels of methamphetamine and cocaine dropped 16 and 42 per cent, respectively (*Environmental Science & Technology Letters*, doi.org/gstb).

Subedi thinks that the decrease in drugs such as cocaine was caused by a tightening of travel restrictions and economic effects of the pandemic. "People could not get it, and they're expensive drugs," he says. "People couldn't afford it: people lost their jobs." Likewise, he believes the rise in prescription drugs found in wastewater was enabled by the shift to telemedicine making it easier to get prescriptions for opioids.

This kind of wastewater analysis is relatively new, but is a useful addition to public health analysis, says Wayne Hall at the University of Queensland, Australia. ▮