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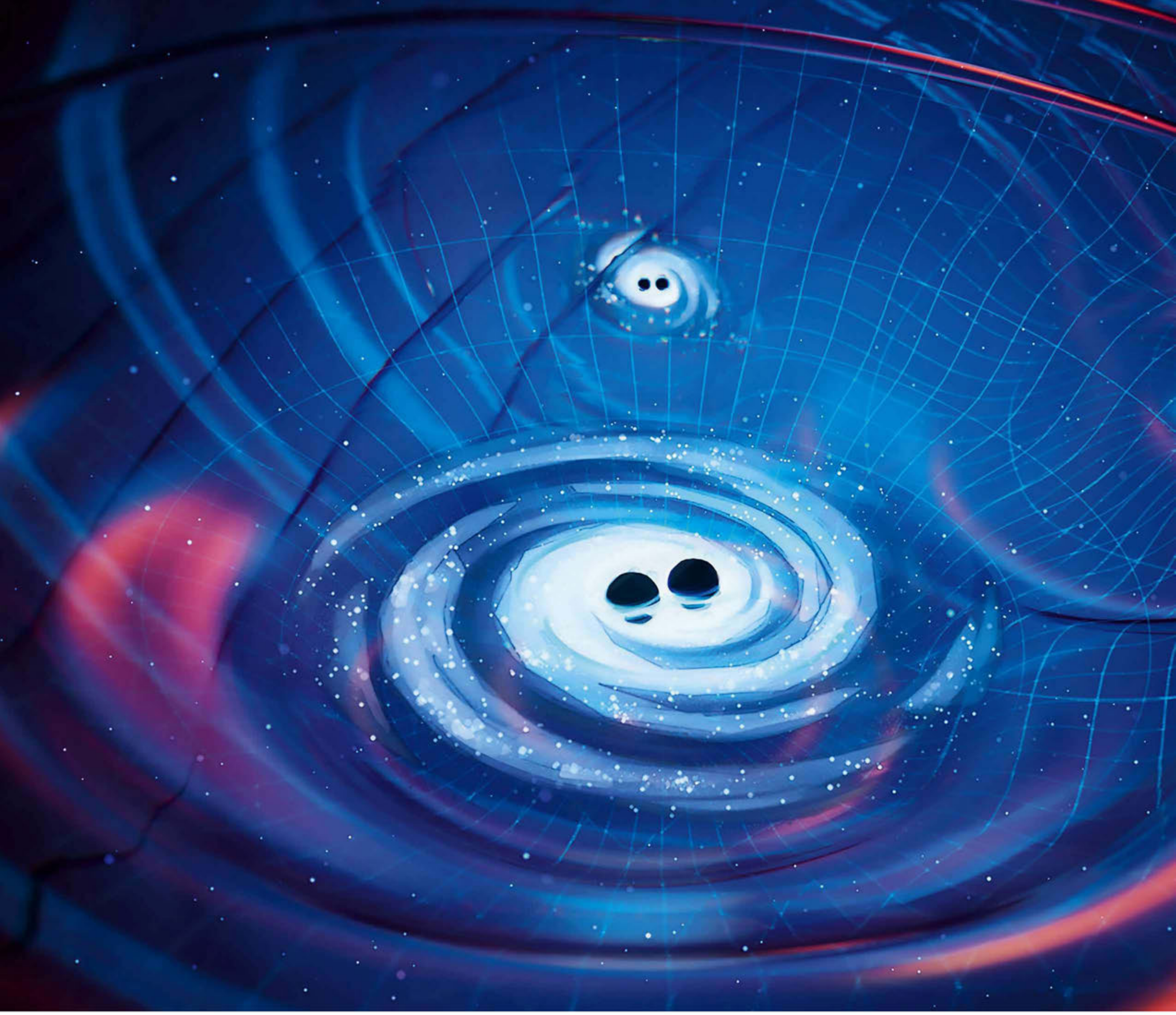

OLENA SHMAHALO/NANOGRAV

COSMOLOGY

GRAVITATIONAL RIPPLES COULD HELP CRACK THE UNIVERSE'S SECRETS

New findings provide evidence of a 'background hum' produced by low-frequency gravitational waves rippling across spacetime

An international team of scientists has found evidence that suggests Earth, and indeed everything in the Universe, is afloat on a constantly rippling sea of low-frequency gravitational waves.

The findings, announced in a series of papers published in *The Astrophysical Journal Letters* were made by the North American Nanohertz Observatory for Gravitational Waves (NANOGrav), a team of researchers from more than 50 institutions in the US and abroad. Together, the papers provide the first evidence of a gravitational wave background – essentially, a soup of spacetime distortions that pervade the entire Universe.

"This is the first-ever evidence for the gravitational wave background. We've opened a new window of observation on the Universe," said NANOGrav scientist Dr Chiara Mingarelli.

For more on this story, read *BBC Science Focus*'s columnist Dr Katie Mack's analysis online at **bit.ly/LowFreqGWaves**

ABOVE The gravitational effects produced by enormous black holes circling each other send distortions rippling across the fabric of spacetime

"We've opened up a new window of observation on the Universe"

Gravity waves were first predicted by Albert Einstein in 1916, but their existence wasn't confirmed until 2015 when they were first detected by the Laser Interferometer Gravitational-wave Observatory (LIGO).

Those waves were of much higher frequencies and come along once in a while, like the waves a surfer might look to catch and ride back to the beach (except created by the collision of two black holes in deep space). The lower-frequency gravitational waves picked up by the NANOGrav scientists are smaller and constant, more akin to the ripples you see on the surface of a calm ocean.

"People compare this signal to more of a background murmur, as opposed to the shouts that LIGO picks up," said Katerina Chatziioannou, an assistant professor of physics at Caltech and a member of the NANOGrav team.

If confirmed, the existence of a gravitational wave background could lead to answers to some of cosmology's biggest questions, from the fate of colliding supermassive black holes to the frequency of galaxy mergers, and maybe even the birth of the Universe.

The higher-frequency gravitational waves detected by LIGO come from smaller pairs of black holes circling each other rapidly in the final seconds before they collide. Lower-frequency gravitational waves are thought to be generated by huge black holes at the hearts of galaxies, up to billions of times the mass of the Sun, that lumber around each slowly and have millions of years to go before they merge.

To detect the lower frequency waves the NANOGrav team used a pulsar timing array (PTA), which measures the radio pulses that spinning neutron stars (pulsars) emit at regular intervals.

When a gravitational wave passes between a pulsar and Earth, the distortions it causes in spacetime cause the pulse to arrive earlier or later than expected... albeit by billionths of a second. By analysing these tiny differences, astronomers are able to determine the nature of the gravitational waves causing the change.

The NANOGrav team used observations of 67 carefully chosen pulsars taken by radio telescopes including the Green Bank Observatory in West Virginia, the Very Large Array in New Mexico, and the Arecibo Observatory in Puerto Rico to effectively create a gravitational wave detector the size of our galaxy.

The team now plans to work with other researchers across Europe, India, China and Australia to investigate the gravitational wave background in more detail.

"Now that we have evidence for [low-frequency] gravitational waves, the next step is to use our observations to study the sources producing this hum," said Sarah Vigeland, an assistant professor of astrophysics at the University of Wisconsin-Milwaukee and chair of the NANOGrav team.