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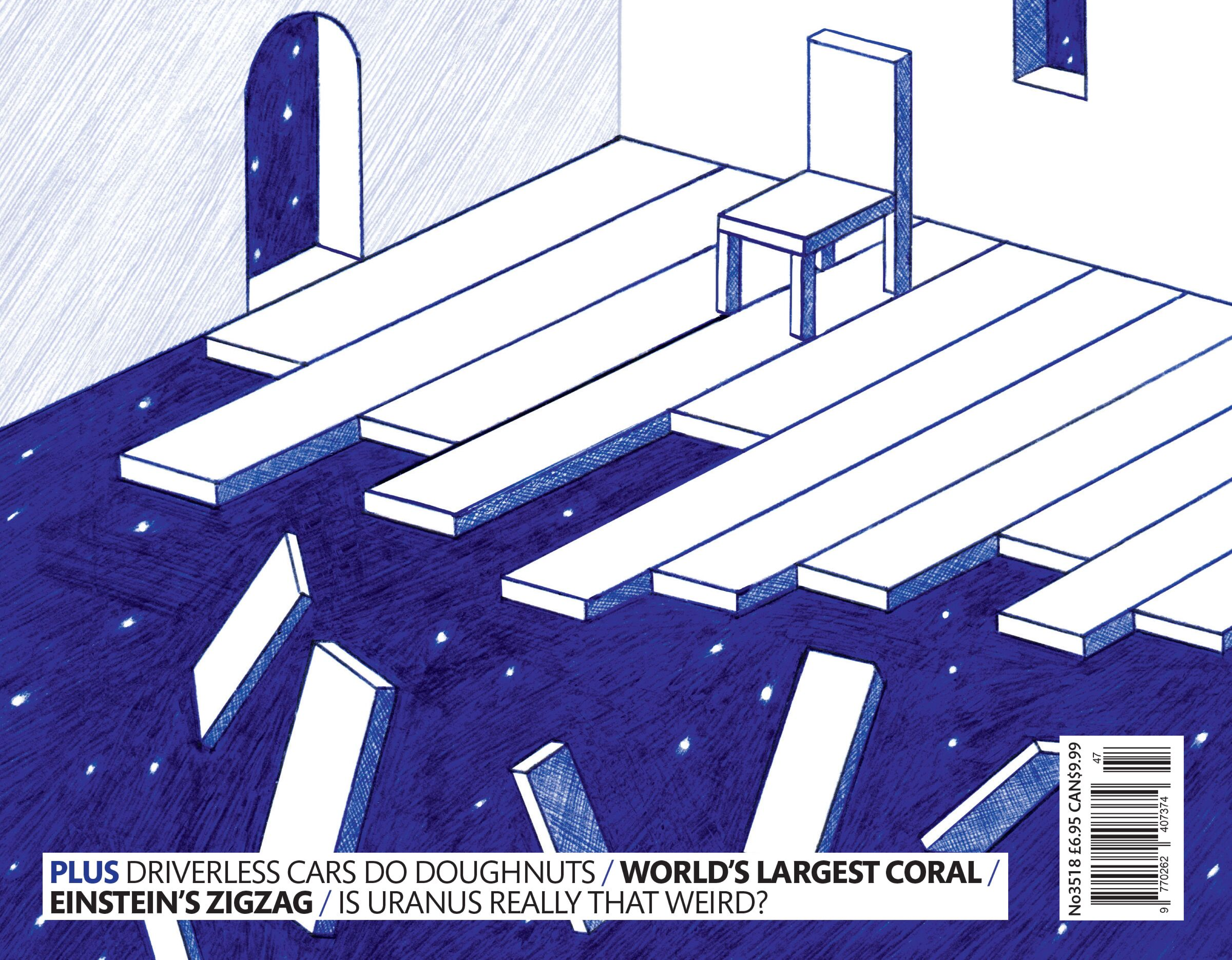

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Astronomy

Galaxies make a zigzag lens

Light from a distant quasar is being deflected by not one but two massive galaxies, giving us a unique opportunity to probe the expansion of the universe, reports **Alex Wilkins**

A CHANCE alignment between two massive galaxies could help astronomers better measure the expansion of the universe and shed light on the mysterious nature of dark energy.

While working on his general theory of relativity, Albert Einstein predicted that light from distant galaxies and stars should be bent by the gravity of very massive objects, similar to how a glass lens bends and magnifies light. Astronomers have since observed hundreds of galaxies, or clusters of galaxies, acting as gravitational lenses, warping and sometimes duplicating the images of galaxies that are sitting behind them.

Now, Martin Millon at Stanford University in California and his colleagues have found an incredibly rare case of two galaxies, 13.4 billion light years apart, both bending the light of a quasar, an incredibly bright supermassive black hole at the centre of a third galaxy.

"This is the only [double gravitational lens] that has been found so far," says Millon. "It's probably a 1-in-50,000 gravitational lens, but we haven't found 50,000 lensed quasars. There's only 300, so it's super strange that we found one."

Astronomers have described this configuration as an "Einstein zigzag lens". The resulting image contains six copies of the original, some of them flipped due to the complicated path that the quasar's light took between the two gravitational lenses.

"We've never seen anything like this before," says Thomas Collett at the University of Portsmouth, UK. While there have been alignments of more than two galaxies, the lensing from the second galaxy has normally been so small as to be irrelevant, he says.

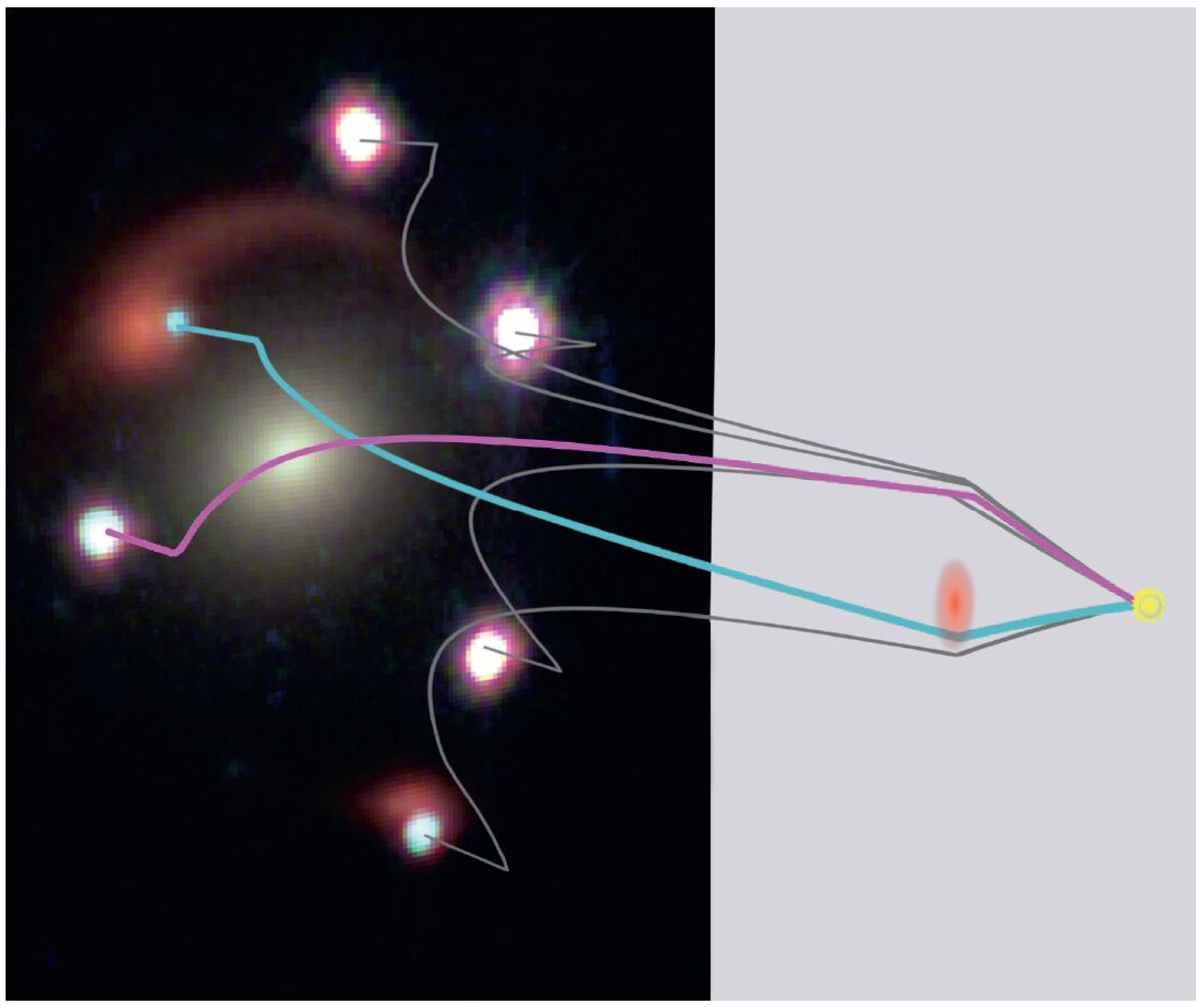
The lens was first spotted in 2021, but astronomers concluded that it was a single lens distorting two quasars behind it. "You can see there is this big, bright yellow galaxy in the centre – that's the main lensing galaxy – and then there is this red arc that was interpreted as another galaxy at the same distance as the source," says team member Frédéric Dux at the Swiss Federal Institute of Technology in Lausanne.

However, new observations with the Nordic Optical Telescope in the Canary Islands and the James Webb Space Telescope revealed that this red arc was in fact a closer galaxy acting as a second lens (arXiv, doi.org/nsc6).

One advantage of seeing a lensed object duplicated six times, rather than four times, which is the standard for a single-source lens, is that it can be used to calculate a more accurate value of the Hubble constant, which measures the rate of expansion of the universe. This could help settle a long-standing cosmological debate over two very different values for the Hubble constant given by two different measurement techniques.

The same pattern of four images can be produced under different values for the Hubble constant depending on how spread out the mass in the lensing galaxy is, but astronomers can't separate out these scenarios. With two lenses, however, you can differentiate between them and measure the Hubble constant more precisely, says Millon.

One of the lensing galaxies is also the most distant lens we know of, at 15.8 billion light years. This presents a unique opportunity to accurately measure the mass of very early galaxies, says Collett. "The really exciting thing here is learning about [this] lens, this galaxy that's halfway to the edge of the universe."



F. DUX ET AL. (2024)

This black square shows six points of light as they appear when viewed in 2D through a telescope, but these are actually all the same quasar. The 3D view shows how light from the quasar (yellow spot) is deflected by two galaxies: one of which is represented by the red spot, the other by the central glow in the black image

15.8 billion
Distance to the furthest lensing galaxy from Earth in light years

13.4 billion
Distance between the two lensing galaxies in light years

1 in 50,000
Proportion of lensed quasars expected to have a zigzag lens

Dark energy clues

Gravitationally lensed systems are one of the most accurate methods we have of measuring the mass of galaxies, but because galaxies in the early universe often haven't had time to grow to a size where they can act as gravitational lenses, there is a gap in our knowledge. "This is the first real opportunity to understand the make-up and contents of galaxies at such a high [distance from Earth], and that's very exciting," says Collett.

The lens system could also tell us about the expansion rate of the universe in the past, at the age of the more distant galaxy. This is tied to the nature of dark energy, the mysterious force that appears to be accelerating the expansion of the universe, says Millon. Measuring the Hubble constant using the double lens system could therefore provide clues to how dark energy accelerated the expansion of the universe in the past billion years, he says. ■