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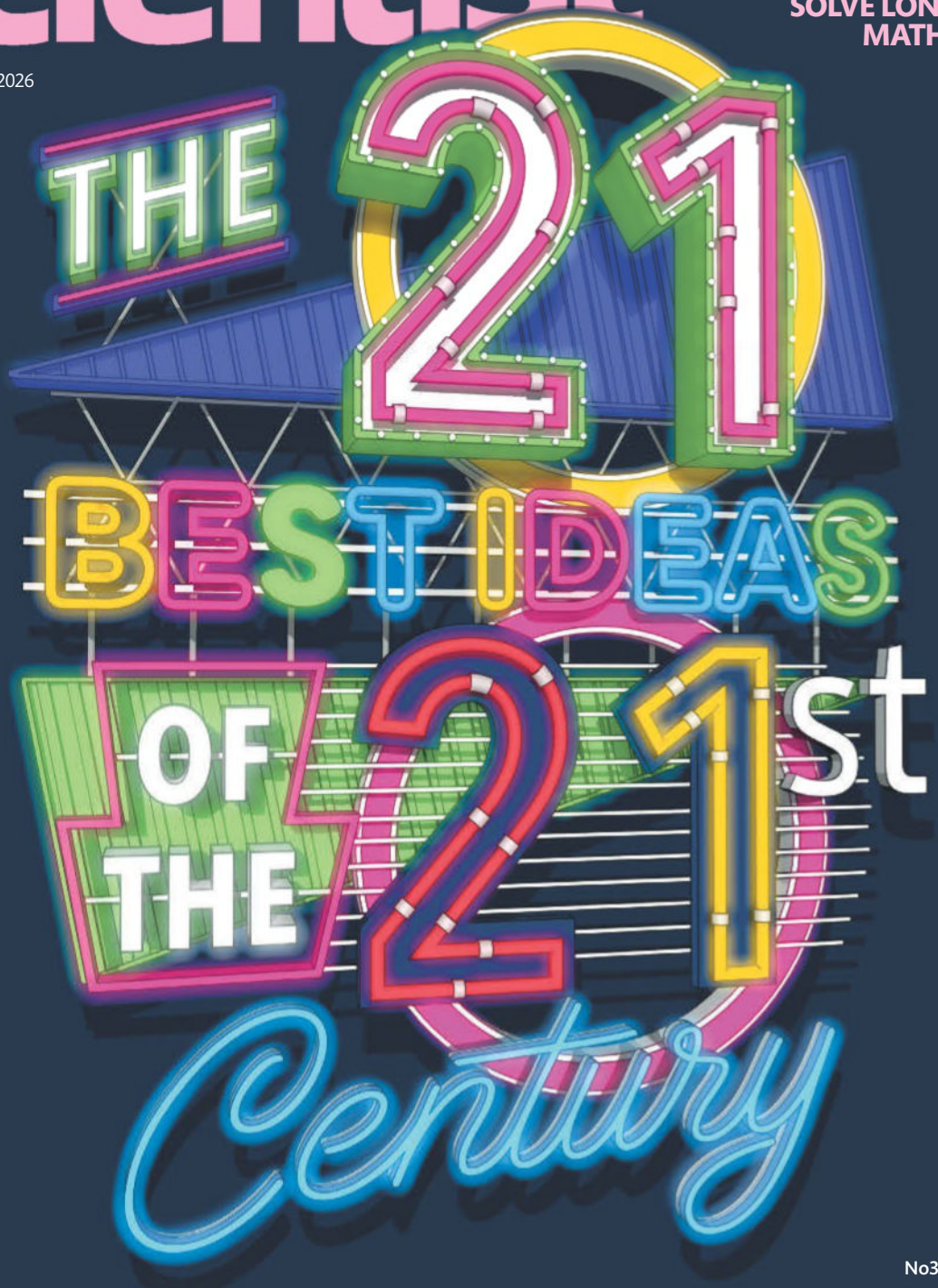

A SPECIAL ISSUE

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Space

Distant 'little red dot' galaxies may contain baby black holes

Alex Wilkins

IMPOSSIBLY bright galaxies discovered by the James Webb Space Telescope (JWST) may not be so bright after all. These galaxies once threatened to upend our understanding of the cosmos by suggesting it contained monstrous black holes or far more stars than we had anticipated, but astronomers now think the galaxies might actually contain "baby" black holes instead.

In its first few years scanning the early universe, JWST unexpectedly discovered hundreds of very red and extremely bright galaxies, which astronomers called "little red dots" (LRDs).

The amount of light coming from these galaxies suggested that they contained either a density of stars far greater than any galaxy we know of, or black holes that were far more massive than astronomers thought possible given the size of their host galaxies.

Both of these scenarios would have required significant adjustments to our models of galaxy formation and black hole growth in the early universe.

NASA, ESA, CSA, STScI, AND D. KOCEVSKI (COLBY U./STScI

These "little red dots" are all bright galaxies spotted by the James Webb Space Telescope

But these conclusions also rested on the assumption that the LRDs' red colour was due to an abundance of dust, either around the black hole itself or surrounding the stars, because that is what is typically found in the very red galaxies of our local universe. However, recent research found a lack of evidence that LRDs contain dust after all.

Jenny Greene at Princeton University and her colleagues think that this finding means we need to reconceive what LRDs are. "We were sure that we could detect the dust emission, if indeed they were red because of dust, and then we did not find that emission at all," says Greene. "That was the big clue that our assumption that they're dusty is just wrong, that's not why they're red."

Previous observations had inferred the total brightness of LRDs by measuring a specific single frequency of light, associated with the element hydrogen, which can then be used to calculate the total brightness, based on typical models of how dust affects this light.

In a new analysis, Greene and her team directly measured the total light emissions from two LRD galaxies by looking at many different frequencies of light, including X-rays and infrared. They found that for most frequencies, apart from visible light, there was much less light being emitted than for typical galaxies, suggesting that the LRDs were at least 10 times dimmer than initial estimates suggested (*Astrophysical Journal*, doi.org/qm5n).

"If there's actually not as much light there as we thought, the black hole masses are probably much more modest," says Greene.

Because the light emissions suggest the black holes contain relatively little mass compared with standard black holes, team member Rohan Naidu at the Massachusetts Institute of Technology says we can think of them as "baby black holes." He adds that this also fits with an emerging picture that the black holes in the LRDs are actually black hole stars – a special class of black hole surrounded by gas.

"In ordinary black holes, what you actually see with your eyes is the tip of the iceberg of the total energy that is coming out of the system, but the little red dots we now understand should really be thought of as these puffed-up black hole stars," says Naidu.

"If there's not as much light there as we thought, the black hole masses are probably more modest"

But Roberto Maiolino at the University of Cambridge says that we can't be sure about the masses of black holes in the LRDs, because the light being emitted from a black hole tells us about its rate of growth, not about its total mass.

Faint star may be a failed supernova

Black holes come in different sizes (see main story) and can form in different ways. One idea is that a particularly massive star could collapse in on itself to form a black hole, rather than exploding in a supernova, and we might now have seen that process in action.

In 2024, Kishalay De at Columbia University in New York and his colleagues observed an unusually bright star called M31-2014-DS1 in the nearby galaxy Andromeda that was around 20 times as massive as our sun. The star appeared to grow brighter in 2014, before becoming dramatically dimmer between 2017 and 2020.

Now, De and his team have observed this star with the James Webb Space Telescope (JWST) and the Chandra X-ray Observatory, finding a faint, red object where the star once was that is around 8 per cent as bright as the original star and shrouded in a cocoon of dust moving rapidly outwards (arXiv,doi.org/qnmjand). This fits with what astronomers think a failed supernova making a black hole would look like.

But in a separate study, Emma Beasor at Liverpool John Moores University, UK, and her colleagues found the observations could just as easily be the result of two stars merging (arXiv, doi.org/qnmk).
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