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THE HUNT FOR BLACK HOLE STARS

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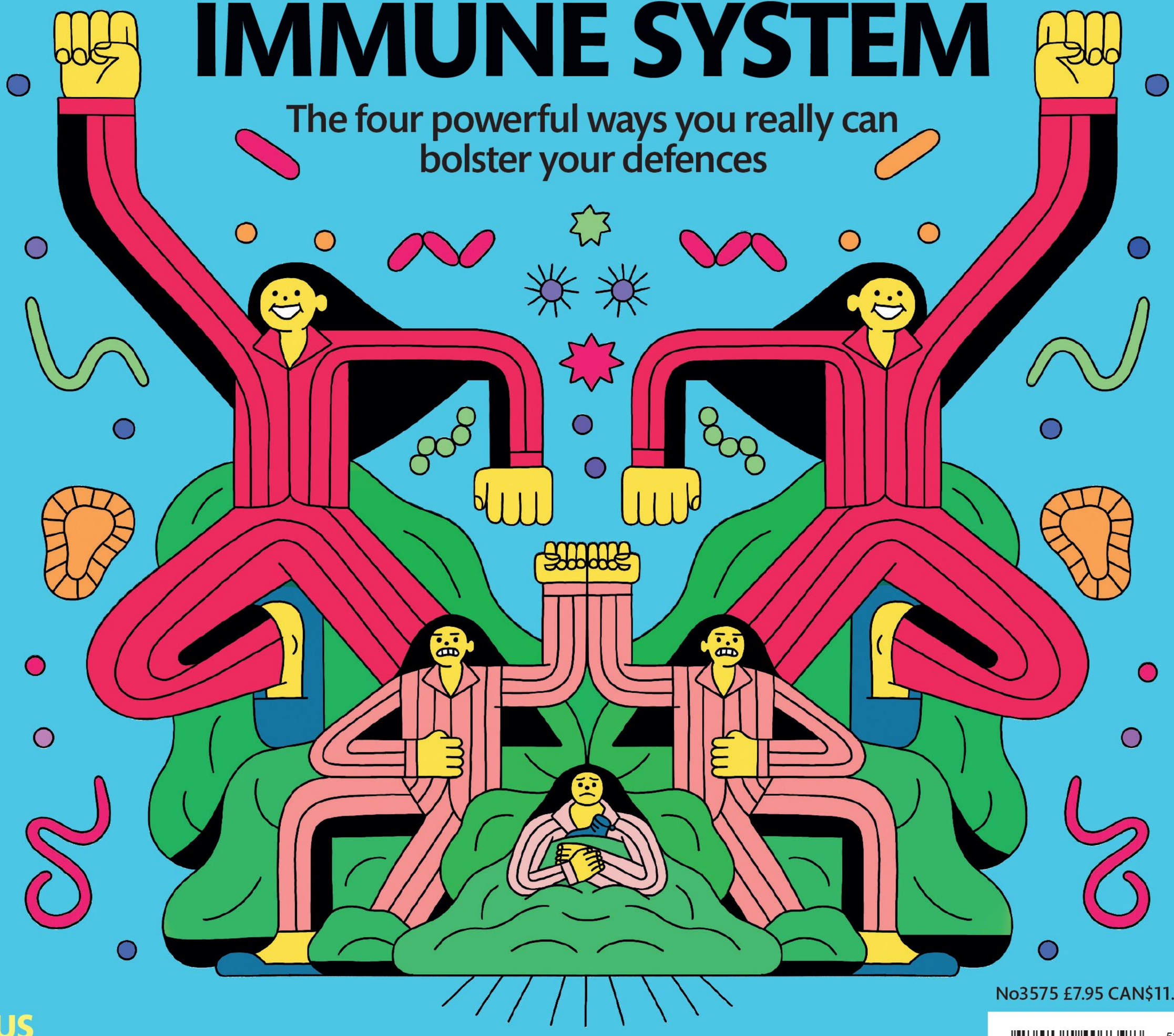

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Black hole stars really do exist

Mysterious 'little red dots' seen by the James Webb Space Telescope can be explained by a new kind of black hole enshrouded in an enormous ball of glowing gas, finds **Alex Wilkins**

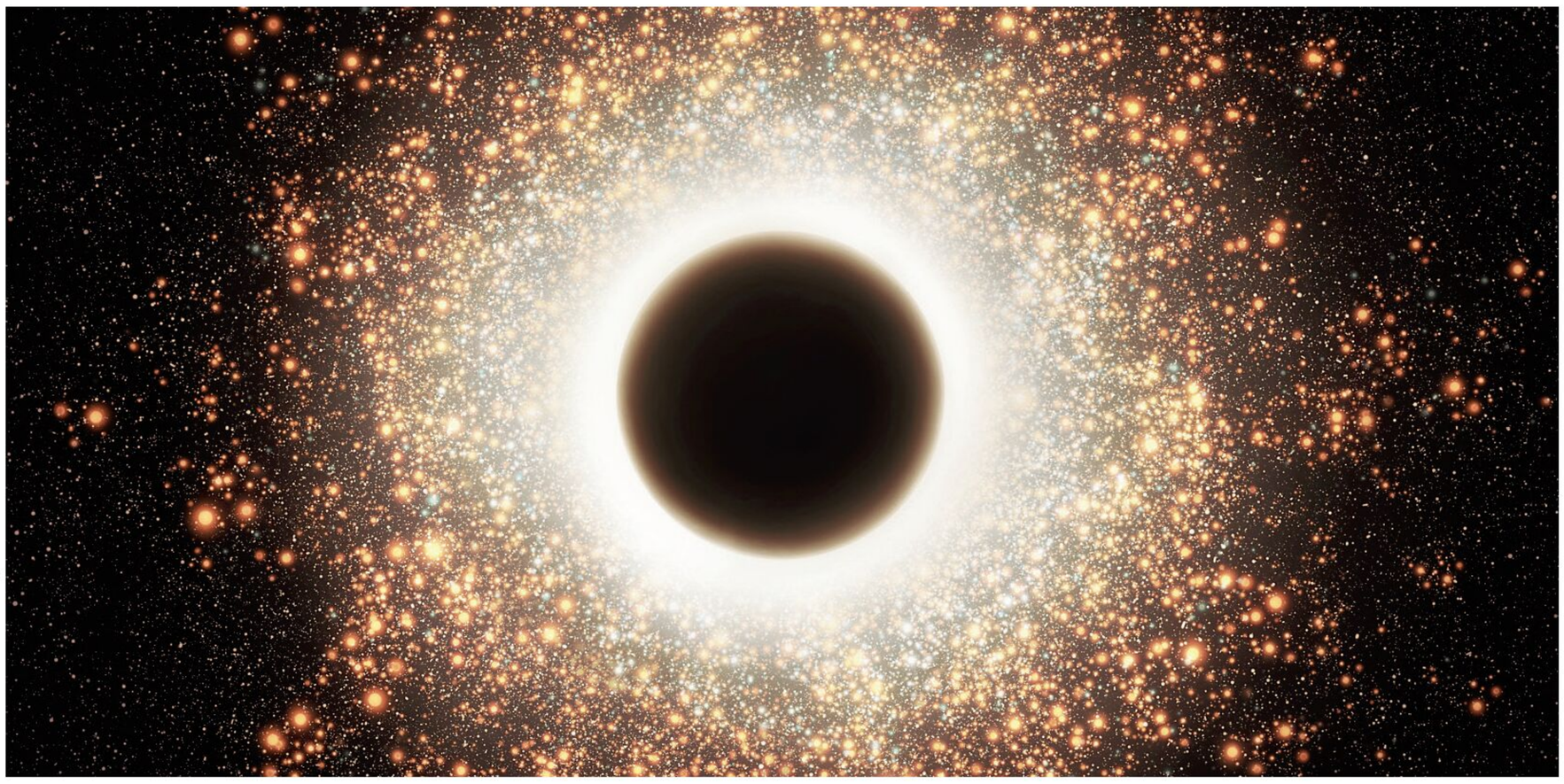
THE early universe appears to be littered with enormous, star-like balls of gas powered by a black hole at their core, a finding that might solve one of the biggest mysteries thrown up by the discoveries of the James Webb Space Telescope (JWST).

When JWST first began peering back to the universe's first billion years, astronomers found a group of what looked like extremely compact, red and very bright galaxies unlike any we can see in our local universe. The most popular explanations for these so-called little red dots (LRDs) were supermassive black holes with dust swirling around them, or galaxies very densely packed full of stars – but neither one fully made sense of the light JWST was detecting.

Earlier this year, astronomers proposed instead that LRDs were dense spheres of gas with a black hole at their centre, called black hole stars. "When material falls into the black hole, a lot of gravitational energy is released, and this could make the whole ball of gas around it glow like a star," says Anna de Graaff at Harvard University. Although the energy doesn't come from nuclear fusion, as in a regular star, the effect is a similar glowing ball of dense gas, just on a far bigger scale, says de Graaff. However, while some LRDs supported this interpretation, it was still controversial.

"The black hole star model was thought to be so weird and out there, but it does seem to work"

Now, de Graaff and her colleagues have analysed the widest sample of LRDs since JWST began its observations, including more than 100 galaxies, and concluded they are best explained by star-like objects, or black hole stars (arXiv, doi.org/qjdp).



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Balls of gas with black holes at their centre could glow like stars

"The name black hole star is, for sure, still controversial, but I do think that there is now a decent consensus in the community that we are looking at an accreting black hole that's enshrouded in dense gas," says de Graaff.

When the team looked at the brightness of light at different frequencies, called a spectrum, coming from the LRDs, the patterns best matched light coming from a single, relatively smooth surface, called a blackbody. This is also how stars appear, in contrast to the more complicated and spiky spectra seen from galaxies, which produce their light from a combination of stars, dust, gas and a central black hole.

"The black hole star model has been around for a while but was thought to be so weird and out there, but it actually does seem to work," says Jillian Bellovary at the American Museum of Natural History in New York.

In September, de Graaff and her colleagues also found a separate, single LRD that had an extremely sharp peak for a frequency of light coming from galaxies, which they nicknamed "The Cliff". "We saw certain features in the spectrum that truly could not be explained by any of our existing models," says de Graaff.

Shine a light

While many astronomers agree LRDs appear to function like vast stars, it will be difficult to prove that what is powering them is a black hole, says de Graaff. "The centre of this object is embedded in this envelope that is very, very dense, or optically thick," she says.

One way of proving they are black holes is by looking at how the light coming from them alters over time, and seeing if they vary like we know black holes do in our local universe, says Xihan Ji at the University of Cambridge. "You see the brightness changing on relatively short timescales, like months or even days, but for these little red dots, there seems to be very little evidence of this variability most of the time."

It can be difficult to look for evidence of longer variations in light from LRDs because JWST has only a limited time to make its observations, but another recent study could give some indication. Fengwu Sun at Harvard University and his colleagues found an LRD whose light had been bent around a very massive galaxy sitting between it and Earth, called a gravitational lens. The lens produced four images of the original LRD, but because the light for each image had travelled different distances to reach us, each one was equivalent to looking at the LRD at different snapshots over a 130-year period.

The four snapshots appear to show a variability in brightness similar to known pulsating stars, but hinting at a far greater width, consistent with the black hole star hypothesis. Sun and his team declined to speak with *New Scientist* for this story.

While using a gravitational lens to measure the LRD at different times is clever, there could be other explanations for this variability, says Bellovary. ▮