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10 mysteries of the universe: What came before the big bang?

Searing bursts of radio waves first spotted a decade ago could come from bouncing black holes – and that suggests a universe might have existed before ours

By **Daniel Cossins**

Mystery: What came before the big bang?

IT WAS gone almost as soon as it came, so it is hardly surprising that we didn't even notice it. Only in 2007, six years after the event, did Duncan Lorimer at West Virginia University and his student David Narkevic spot it. They were scouring archived data from the Parkes radio telescope in New South Wales, Australia, when they noticed a burst of radio waves of almost unimaginable ferocity. Lasting less than 5 milliseconds, it hit Earth on 24 July 2001, releasing roughly as much energy as the sun spits out over five days.

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Since then, we have picked up over 30 more such fast radio bursts (FRBs) – and there is precisely zero consensus on what generates them. Suggestions range from colliding neutron stars to alien spacecraft. The explanation that sits most neatly in the sweet spot between jaw-dropping and not entirely implausible, however, is one that credits bouncing black holes as the bursts' source. As if that weren't enough to swallow, that could also mean the cosmos did not begin in a big bang.

"Evidence is building up to support the idea that the big bang might not have been the beginning"

At the heart of this radical idea lie singularities, phenomena that arise out of Einstein's general relativity. This theory explains how gravity arises through the warping of space-time, and thus how the entire universe evolves.

Singularities occur where Einstein's equations cease to make any sense, because mass is so concentrated that space-time becomes infinitely warped – places like the interiors of black holes. By general consensus, what we need to wipe out these annoying singularities is a quantum theory of gravity, in which space-time is not a smooth and infinitely malleable fabric, but instead comes in discrete chunks.

In 2014, Carlo Rovelli at the University of Aix-Marseille in France and Francesca Vidotto, now at the University of the Basque Country in Spain, realised that there is a limit to how much these chunks can be warped and compressed. When a black hole reaches a certain density, gravity would be overcome by outward pressure from space-time itself. The result is a quantum bounce, an explosion that transforms the black hole into a "white hole" that spews out everything its predecessor consumed. Within the framework of one particular quantum gravity theory, loop quantum gravity, Rovelli, Vidotto and Aurélien Barrau at the University of Grenoble-Alpes, France, showed that the bouncing of primordial black holes – gravitational mini-monsters thought to have formed in the aftermath of the big bang – could produce high-frequency radio signals in the same ballpark as FRBs.

It's not possible to confirm the existence of a white hole based on a single burst. But if their idea is right, the researchers have identified a pattern that should emerge given enough FRB sightings.

And here's the thing, says Barrau: the big bang is a singularity, too. What's more, "the structure of the singularity inside black holes is not very different from the one at the big bang. If black holes do bounce, it is highly probable that the universe did too." Rather than emerging from nothing, perhaps the cosmos we know formed when a previous one contracted until it could shrink no more, and then… BOING! The lesson of fast radio bursts could be that the beginning was anything but the beginning.

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