BBC

A TOURIST'S GUIDE TO THE QUANTUM UNIVERSE

Science Focus

HOW TO CUT YOUR RISK OF HEART DISEASE

7 surprising habits that could help you live longer

THE MYSTERIOUS PEACEFULNESS OF NEAR-DEATH EXPERIENCES

THE NEW HUNT FOR A REAL-LIFE ATLANTIS

STRANGE ENERGY SIGNALS FROM A GALAXY FAR, FAR AWAY

SF
SCIENCEFOCUS.COM
03 >
ISSUE #417 MARCH 2025
UK £5.99 US $13.50 CAN $14.99
AUS $14.50 NZ $19.99

THE BIG QUESTION

Fast radio bursts: Are these mysterious signals from deep space getting even stranger?

New discoveries are shaking up what little we thought we knew about fast radio bursts

by TOM HOWARTH

Fast radio bursts (FRBs) are among the greatest cosmic enigmas of our time. First discovered in 2007, these fleeting flashes of radio waves have been puzzling astronomers ever since. Despite detecting thousands of them, we still don't know exactly what causes them, where they come from or why they behave so unpredictably.

Just when scientists thought they were beginning to piece together the puzzle, two new studies, published in January this year, threw a spanner in the works, challenging previous theories and adding new layers of intrigue to the FRB mystery.

"FRBs are one of these mysteries of the Universe that deserves to be solved," says Dr Tarraneh Eftekhari, a radio astronomer at Northwestern University, in the US, and lead author of first of the new papers published in *The Astrophysical Journal Letters*. A solution may well be long overdue, but the Universe, it seems, isn't giving up its secrets just yet.

"An FRB that's one millisecond long could emit the same amount of energy as the Sun produces in three days"

WHAT'S SO MYSTERIOUS ABOUT FRBS?

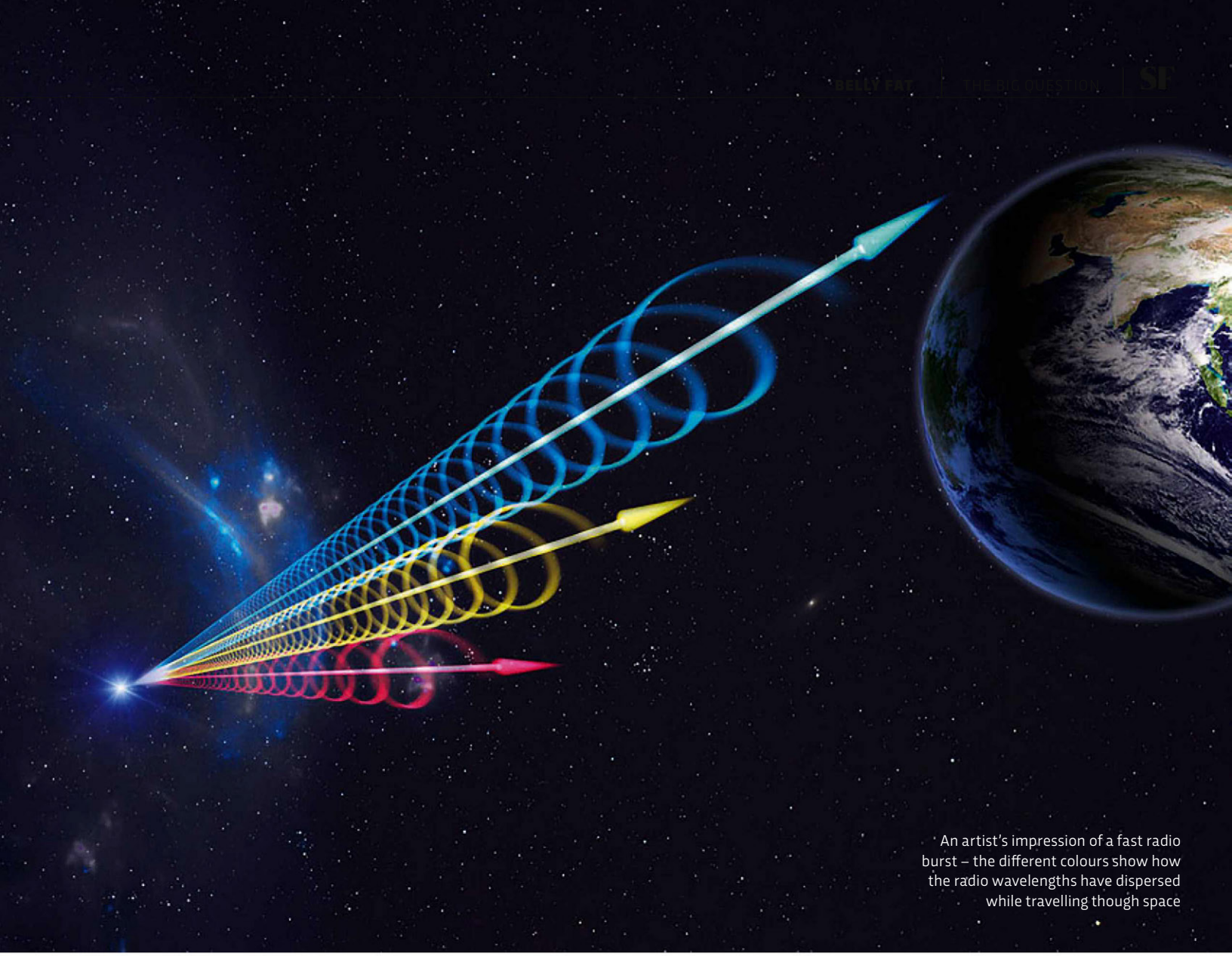
While it wouldn't be quite right to say that FRBs were discovered by accident, it's true that when first spotted, they were buried within data collected for an entirely different purpose: tracking down pulsars.

Pulsars, or 'pulsating radio sources', are a far better understood cosmic phenomenon. They were discovered in 1967 by Prof Jocelyn Bell Burnell and are known to originate from neutron stars – the incredibly dense remnants of massive stars that boast magnetic fields trillions of times stronger than Earth's. These fast-spinning stellar corpses emit regular pulses of radio waves, acting like cosmic lighthouses.

The regularity of the pulses Bell spotted, and the fact they were being emitted at a very specific frequency, hinted that they might be artificially, rather than naturally, generated and led her to nickname that first pulsar "Little Green Man 1". But while pulsars quickly found their place in the astrophysical playbook, FRBs are a different story.

Fast-forward 40 years to 2007, when astronomers poring over data from the Parkes Multibeam Pulsar Survey

JINGCHUAN YU/BEIJING PLANETARIUM/NRAO



An artist's impression of a fast radio burst – the different colours show how the radio wavelengths have dispersed while travelling though space

(an international collaboration between groups at Jodrell Bank Observatory, the Massachusetts Institute of Technology, Bologna Astronomical Observatory and the Australia Telescope National Facility) stumbled upon something entirely unexpected: an ultra-short, incredibly bright burst of radio waves from deep space. This emission was so powerful that it outshone all other known sources at the time by a truly colossal amount.

"In terms of energy output, an FRB that's one millisecond long could emit the same amount of energy as the Sun produces in three days," says Dr Fabian Jankowski, an astrophysicist specialising in FRBs at France's National Centre for Scientific Research.

Yet, for more than five years after this first detection, no others were found, leading some to question whether FRBs were real at all. That scepticism faded as more began to surface. Since then, thousands have been detected, though astronomers estimate that two to three FRBs could be flashing across the sky every minute – suggesting we're only aware of a fraction of the full amount.

Mysterious signals from deep space, emitting mind-boggling amounts of energy, filling the sky. So far, so strange. But the strangeness doesn't end there.

Initially, FRBs were thought to be one-off events – cosmic flukes, appearing once and never again. This assumption seemed solid; despite countless hours of follow-up observations, none of the sources ever repeated.

That changed in 2016, when an FRB known as FRB 121102 was spotted emitting repeated bursts. It's now thought that between 3 and 10 per cent of FRBs are so-called 'repeaters'. Why some FRBs emit a single burst and then remain stubbornly silent, while others emit multiple bursts is yet another mystery waiting to be solved.

WHAT'S CAUSING FRBS?

There are plenty of theories about what FRBs could be, from cataclysmic black hole collisions to aliens (even astronomers accidentally detecting meals cooking in their microwaves). But one candidate currently stands head and shoulders above the rest.

"We know that when very massive stars collapse and go supernova, they leave behind these highly magnetised neutron stars, or 'magnetars'," says Eftekhari. "The reason why magnetars are such compelling candidates for FRBs is that we've detected FRB-like events from a known magnetar that's in the Milky Way."

Neutron stars already boast incredibly strong magnetic fields, but magnetars exist in a league of their own, with fields thousands of times more powerful than an ordinary neutron star.

Adding to the weight of evidence stacked in magnetars' favour is that →

→ most FRBs are found in galaxies with high rates of star formation. This is key because, as Eftekhari says, "you need massive stars to go supernova and leave behind magnetars. And you find massive stars in galaxies that are producing stars."

So, case closed, right? Not quite. This is where the two new studies published in January come in, both of which focused on a repeating FRB known as 20240209A.

"The first exciting thing about this FRB is that it was located way outside of its galaxy," says Vishwangi Shah, a PhD student at McGill University in the US, and lead author of the second paper. "There's only one other FRB that has been localised outside of a galaxy and for that repeater, we know that it's coming from a globular cluster."

Both Eftekhari and Shah suspect that 20240209A also resides in a globular cluster (a dense collection of old stars that linger on the outskirts of a galaxy).

"This was surprising," Eftekhari says. "It kind of challenges the magnetar progenitor idea because you would really need a population of young stars to be producing magnetars."

But what does all this mean for FRBs? One possibility is that magnetars are still the culprits, but they could be forming through a completely different process. For instance, two normal neutron stars might merge in these stellar graveyards, creating a magnetar. Alternatively, a white dwarf – the remnants of a star too small to become a neutron star – could accrete matter from a nearby partner, eventually triggering a massive explosion and leaving a magnetar behind.

Ultimately, though, no one really knows what's behind these outlier events. "It's just exciting to think that we might be dealing with subpopulations of FRBs here," Eftekhari says. "The case isn't as clear-cut as it had started to seem."

"There's only one other FRB that has been localised outside of a galaxy and for that repeater, we know that it's coming from a globular cluster"

by TOM HOWARTH
Tom is a freelance science writer and was previously a science communicator at the European Southern Observatory.

WILL WE EVER KNOW WHAT AN FRB IS?

Despite nearly two decades of research, many questions about FRBs remain. What objects are responsible for them? What processes drive these events? And why do some FRBs repeat while others don't?

Answers may be closer than we think, thanks to upcoming advances in the field of FRB detection.

The recent discovery of 20240209A was made using the Canadian Hydrogen Intensity Mapping Experiment (CHIME), a new type of radio telescope that's already detecting two to three FRBs a day – more than any other telescope. CHIME is currently undergoing upgrades that'll allow it to pinpoint bursts with unprecedented precision.

This ability to locate FRBs marks a major step forward in solving the mysteries surrounding them. While many FRBs have been detected, only a handful have had their environments precisely identified, leaving key questions about their origins unanswered. Jankowski believes we'll uncover many more cases like 20240209A in the years to come, potentially unlocking the mechanisms behind them. "I think we'll make huge progress," he adds.

The Square Kilometre Array (SKA) – a massive observatory spanning Australia and South Africa – is also set to join the hunt for FRBs in the near future. Eftekhari and Shah have also submitted a proposal to use the James Webb Space Telescope to investigate the region where 20240209A was detected, in hopes of confirming whether it did come from a globular cluster after all.

"It's a really exciting time in the study of FRBs," Jankowski says. "We could be getting some really major discoveries in the next few years." SF

The CHIME radio telescope, in Canada, detected FRB 20240209A, which may have come from a globular cluster

CHIME EXPERIMENT