Flip-flopping magnetic fields hint at a solution for puzzling fast radio bursts from space

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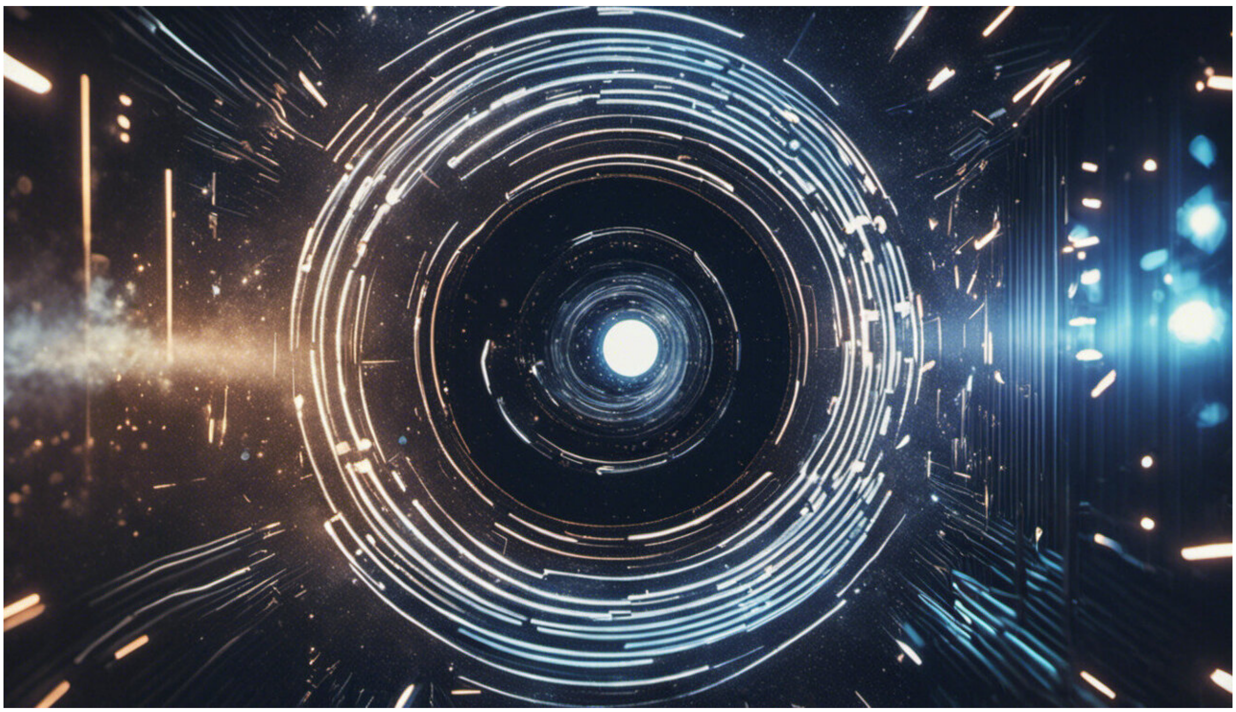


Credit: AI-generated image (disclaimer)

Fast radio bursts—intense, milliseconds-long flashes of radio energy from outer space—have puzzled astronomers since they were first spotted in 2007. A single burst can emit as much energy in its brief life as the Sun does in a few days.

The great majority of the short-lived pulses originate outside our Milky Way galaxy. We don't know what produces most of them, or how.

In new research published in *Science*, we observed a repeating fast radio burst for more than a year and discovered signs it is surrounded by a strong but highly changeable magnetic field.

Our results suggest the source of this cosmic explosion may be a binary system made up of a neutron star whirling through winds of dense, magnetized plasma produced by a massive companion star or even a black hole.

A fast radio burst that never stops repeating

The repeating burst known as FRB 20190520B was discovered in 2022 by astronomers at the Five-hundred-meter Aperture Spherical radio Telescope (FAST) in China. Repeating fast radio bursts are rare, but FRB 20190520B is the rarest of all: it is the only one that never rests, producing radio bursts a few times an hour, sometimes at multiple radio frequencies.

After this intriguing object was first found, astronomers rushed to follow up the initial observation using other radio wavelengths.

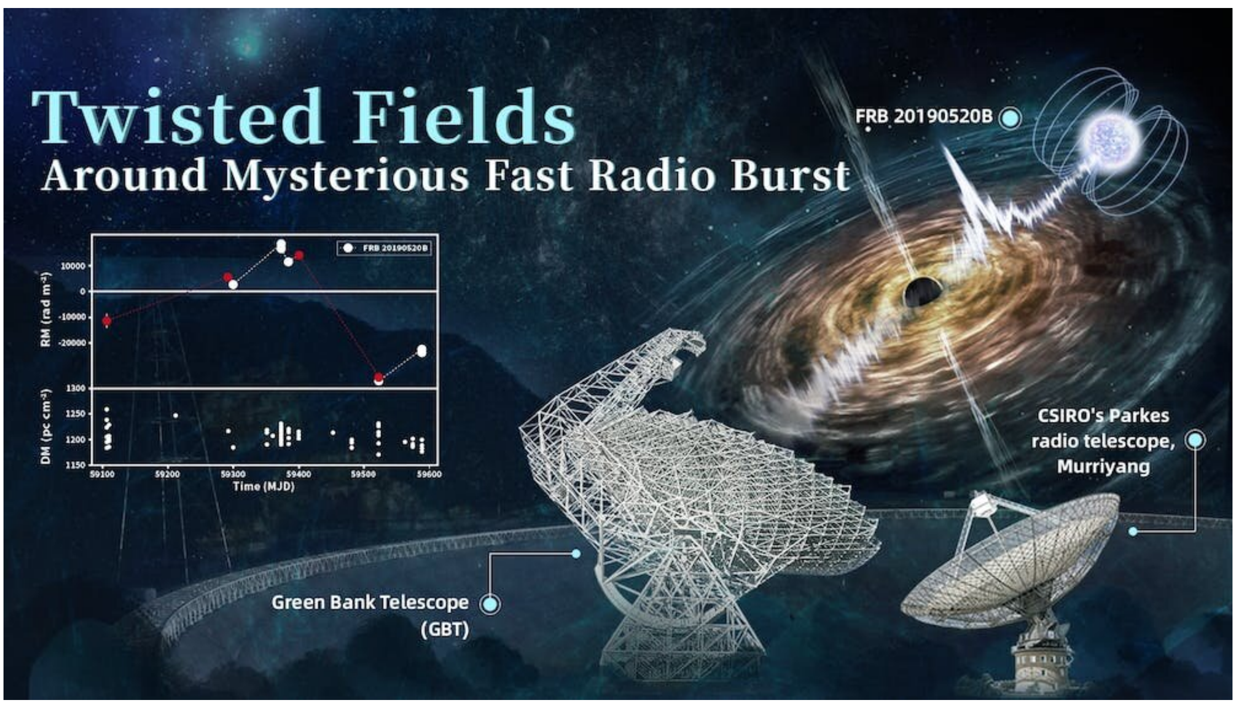
Further investigation showed FRB 20190520B resides in an extremely dense environment in a dwarf galaxy 3.9 billion light years away. There are also materials surrounding the FRB source that produce strong, persistent radio emissions.

This led to suggestions that the bursting source is a young neutron star in a complex environment.

Powerful magnetic fields

What else can we learn about this intergalactic firecracker and its environment? We carried out observations of FRB 20190520B using CSIRO's Parkes radio telescope, Murriyang, in New South Wales and the Green Bank Telescope in the United States.

To our surprise, FRB 20190520B turned out to produce strong signals at relatively high radio frequencies. These high-frequency signals turned out to be highly polarized—which means the electromagnetic waves are "waving" much more strongly in one direction than in others.



Changes in the magnetic field around a repeating fast radio burst hint at the nature of its origin. Credit: Di Li / ScienceApe / Chinese Academy of Science

We found the direction of this polarization changes at different frequencies. Measuring how much it changes tells us about the strength of the magnetic field the signal has traveled through.

As it turns out, this polarization measure suggests the environment around FRB 20190520B is highly magnetized. And what's more, the strength of the magnetic field appeared to vary over the 16 months we observed the source—and even flipped direction entirely twice.

This change in direction of the magnetic field around a fast radio burst has never been observed before.

Filling in the picture

What does this tell us about FRB 20190520B? Most popular theories to explain recent observations of repeating fast radio bursts involve binary systems made up of a neutron star and either another massive star or a black hole.

While we cannot rule out other hypotheses yet, our results favor the massive star scenario.

Massive stars are known to have strong stellar winds with organized magnetic fields around them. If the source of the bursts were moving in and out of the stellar wind region as it travels through its orbit, we would expect the observed magnetic field direction to reverse.

The time scale of the magnetic field reversal, the measured variability in the apparent field strength, and the dense plasma surrounding the burst source all fit into this picture.

What's next?

Our observations might provide crucial evidence to support the hypothesis that sources of repeating fast radio bursts have a massive companion capable of producing highly magnetized plasma.

More importantly, the binary hypothesis gives us a prediction for the future. If it is correct, the changes in polarization of the radio signals from FRB 20190520B should rise and fall over longer periods of time.

So we will be watching. Future observations with Murriyang and the Green Bank Telescope will reveal whether FRB 20190520B is truly in a binary system—or whether the Universe will surprise us once again.

Provided by The Conversation

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