

Cosmic bursts unveil universe's missing matter

May 27 2020



The FRB leaves its host galaxy as a bright burst of radio waves. Credit: ICRAR

Astronomers have used mysterious fast radio bursts to solve a decades-old mystery of "missing matter," long predicted to exist in the universe, but never before detected. The researchers have determined that all of the unaccounted normal matter exists in the vast space between stars and galaxies, as detailed today in the journal *Nature*.

Lead author Associate Professor Jean-Pierre Macquart, from the Curtin University node of the International Centre for Radio Astronomy Research (ICRAR) said astronomers have been searching for the missing matter for almost 30 years.

"We know from measurements of the Big Bang how much matter there was in the beginning of the [universe](#)," he said. "But when we looked out into the present universe, we couldn't find half of what should be there. It was a bit of an embarrassment. Intergalactic space is very sparse. The missing matter was equivalent to only one or two atoms in a room the size of an average office. So it was very hard to detect this matter using traditional techniques and telescopes."

The researchers were able to directly detect the missing matter using the phenomenon of [fast radio bursts](#)—brief flashes of energy that appear to come from random directions in the sky and last for just milliseconds. Scientists don't yet know what causes them, but it must involve incredible energy, equivalent to the amount released by the sun in 80 years. They have been difficult to detect as astronomers don't know when and where to look for them.

Associate Professor Macquart said the team detected the missing matter by using fast [radio](#) bursts as "cosmic weigh stations."

"The radiation from fast radio bursts gets spread out by the missing matter in the same way that you see the colours of sunlight being separated in a prism," he said. "We've now been able to measure the distances to enough fast radio bursts to determine the density of the universe. We only needed six to find this missing matter."

The missing matter in this case is baryonic, or 'normal' matter—like the protons and neutrons that make up stars, planets and humans. It's different from dark matter, which remains elusive and accounts for

about 85% of the total matter in the universe.

Co-author Professor J. Xavier Prochaska, from UC Santa Cruz, says scientists have unsuccessfully searched for this missing matter with the largest telescopes for more than 20 years. "The discovery of fast radio bursts and their localisation to distant galaxies were the key breakthroughs needed to solve this mystery," he said.

Associate Professor Ryan Shannon, another co-author from Swinburne University of Technology, said the key was the telescope used, CSIRO's Australian Square Kilometre Array Pathfinder (ASKAP) radio telescope. "ASKAP both has a wide field of view, about 60 times the size of the full moon, and can image in high resolution," he said. "This means that we can catch the bursts with relative ease and then pinpoint locations to their host galaxies with incredible precision.

"When the burst arrives at the telescope, it records a live action replay within a fraction of a second," said Dr. Keith Bannister from Australia's national science agency, CSIRO, who designed the pulse capture system used in this research. "This enables the precision to determine the location of the fast radio burst to the width of a human hair held 200 meters away," he said.

Associate Professor Macquart said the research team had also pinned down the relationship between how far away a fast radio burst is and how the burst spreads out as it travels through the universe. "We've discovered the equivalent of the Hubble-Lemaitre Law for galaxies, only for fast radio bursts," he said. "The Hubble-Lemaitre Law, which says the more distant a galaxy from us, the faster it is moving away from us, underpins all measurements of galaxies at cosmological distances."

The fast radio bursts used in the study were discovered using ASKAP, which is located at the Murchison Radio-astronomy Observatory in

outback Western Australia. The international team involved in the discovery included astronomers from Australia, the United States and Chile. ASKAP is a precursor for the future Square Kilometre Array (SKA) telescope. The SKA could observe large numbers of fast radio bursts, giving astronomers greater capability to study the previously invisible structure in the universe.

"A census of baryons in the universe from localized fast radio bursts" was published in *Nature* on May 28, 2020.

More information: A census of baryons in the Universe from localized fast radio bursts, *Nature* (2020). [DOI: 10.1038/s41586-020-2300-2](https://doi.org/10.1038/s41586-020-2300-2), www.nature.com/articles/s41586-020-2300-2

Provided by International Centre for Radio Astronomy Research

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