Research Highlight

The first host galaxy for a Fast Radio Burst

Why this is important

This was the first precise localization of a fast radio burst and the first direct distance measurement. This result allowed us to understand the energetics of FRBs, the type of environment in which it was formed and gave clues to what sort of objects could dwell there.

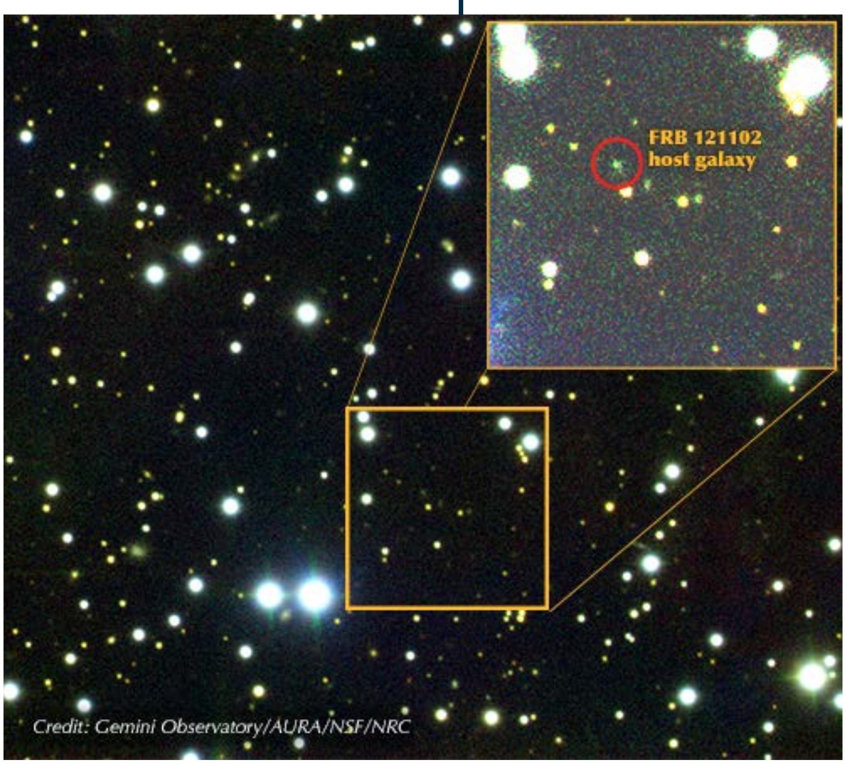
Dr. Shriharsh Tendulkar *is a Trottier postdoctoral fellow working under the supervision of Prof. Victoria Kaspi. His research interests include exploring the origins of fast radio bursts (FRBs) with CHIME and other telescopes and studying high energy phenomena in magnetars.*

Fast radio bursts (FRBs) are incredibly bright, mysterious flashes of radio light that last for only a few milliseconds and seem to be coming from all directions in the sky. Current observations suggest that these events are incredibly common — several thousand go off every day across the whole sky.

FRBs appear to come from extragalactic distances, suggesting that they are a trillion times brighter than the brightest radio pulses from pulsars, the rotating neutron stars typically associated with blips of radio light in our galaxy.

Since the first FRB was detected 10 years ago, their causes and their origins remained a mystery. One key step to solving this puzzle is to find the exact location on the sky of an FRB to see if they have counterparts at other wavelengths of light.

A group lead by MSI postdoc Shriharsh Tendulkar used the Very Large Array (VLA, multi-dish radio telescope array in New Mexico) to successfully pinpoint the exact location of a FRB for the first time. This observation was made possible because one FRB (FRB 121102, named after the date of the initial burst in 2012) was seen to burst more than once, a pattern first detected in late 2015 by former McGill Space Institute PhD student Paul Scholz.



While FRB 121102, sends out bursts on an unpredictable schedule, Tendulkar's team was able to use 83 hours VLA observations over six months to observe nine bursts from FRB 121102 and determine its exact location. At first, the only image the team had was a quick snapshot image taken by the Keck telescope in Hawai'i. It showed a small smudge at the location of the radio observations. While it was unclear whether the smudge was a star or a tiny galaxy, they found it puzzling that such a big flash of radio light could come from such a small, blurry object.

To try and determine what exactly the smudge was, the team took a spectrum of the object with the Gemini telescope. As they waited for data to download, Tendulkar

« Gemini telescope image showing the host galaxy of FRB 121102

discussed the worst case scenarios with a collaborator, fearing that they might have to spend a considerable amount of effort over many days to make sense out of a faint signal.

However, they were pleasantly surprised, “As soon as we opened the files,” Tendulkar said, “we just shouted in joy because it was clear from the extremely bright signatures of hydrogen and oxygen molecules that it was a galaxy that was forming stars at a rapid rate. Within 20 minutes, we were able to announce to the rest of the collaboration the distance to the FRB, and the type of galaxy it was in.”

The host of the FRB was a dwarf galaxy with about a thousandth as many stars as the Milky Way, about 3 billion light years away from the Earth. While the discovery was able to definitively prove that FRBs come from distant galaxies (and not from within the Milky Way), the nature of the host galaxy poses additional questions.

“The host galaxy for this FRB appears to be a very humble and unassuming dwarf galaxy, which is less than 1% of the mass or our Milky Way galaxy,” Tendulkar said. “That’s surprising. One would generally expect most FRBs to come from large galaxies which have the largest numbers of stars and neutron stars — remnants of massive stars. This dwarf galaxy has fewer stars, but is forming stars at a high rate, which may suggest that FRBs are linked to young neutron stars. There are also two other classes of extreme events — long duration gamma-ray bursts and superluminous supernovae — that frequently occur in dwarf galaxies, as well. This discovery may hint at links between FRBs and those two kinds of events.”

The newly-built Canadian Hydrogen Intensity Mapping Experiment (CHIME), an interferometric radio telescope in British Columbia, could help answer some of the remaining questions about FRBs. CHIME will survey half the sky each day, and may detect dozens of FRBs per day. MSI professor and FRB researcher Victoria Kaspi notes that “Once we understand the origin of this phenomenon, it could provide us with a new and valuable probe of the Universe.”

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