Localizing the Fast Radio Burst FRB 121102

Shami Chatterjee
Cornell University
FRB 121102: It repeats!

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→ A better-than-random location to go fishing.
So where is it?

Arecibo detection beams cover dozens of sources in higher resolution VLA observations.

Original detection (Spitler et al. 2014) was apparently in a sidelobe.
VLA localization

Fast sampled visibility data \((u, v, t, f)\).

\(\rightarrow\) 2.5 – 3.5 GHz.
\(\rightarrow\) 256 channels, 4 MHz each.
\(\rightarrow\) 5 ms visibility sampling.
\(\rightarrow\) 351 baselines.

\(=\) 1 TB/hr correlated data. (Set by correlator throughput limit.)
VLA localization

Fast sampled visibility data \((u, v, t, f)\).

**Beam-formed Search:**

- Tile region with phased-up beams.
- Search for pulse in time domain \((t, \text{DM})\).
VLA localization

Fast sampled visibility data \((u, v, t, f)\).

Millisecound Imaging:

- De-disperse visibilities, make images for each sample time.
- Search for transient source in image domain.
VLA localization

Fast sampled visibility data \((u, v, t, f)\) for \(\sim 83\) hours of observing.

**Millissecond Imaging:**
- De-disperse visibilities, make images for each sample time.
- Search for transient source in image domain.

**Beam-formed Single-pulse Search:**
- Tile region with phased up beams.
- Search for pulse in time domain \((t, DM)\).
VLA localization: success!

Detection within 5 hrs – working towards real-time.
See: realfast.io
VLA beam-forming: pulse sweep

Pulse S/N ratio peaks at the image peak pixel.

Lines indicate $v^{-2}$ sweep.

Work by graduate student Robert Wharton.
Field Variability

- 69 sources detected in ~most epochs.
- Variability is common.

$$m_I = \frac{\sigma_S}{\langle S \rangle}$$
Field Variability

69 Sources

22 Epochs

\[ m_I = \frac{\sigma_s}{\langle S \rangle} \]
Field Variability

Host counterpart: variability may be necessary, but not sufficient.
Radio counterpart

- Persistent, variable, 180 $\mu$Jy radio counterpart.
- Separation $<15$ mas ($<40$ pc at 1 Gpc).
Optical counterpart

Deep imaging with Gemini:
25th magnitude counterpart.

- Dwarf galaxy.
- Emission dominated by spectral lines.
- $z = 0.193$; host is $\sim 1$ Gpc away.
What is the persistent radio source?

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What is the persistent radio source?

• Bursts appear to be sporadic, not a constant rate.

• Spectrum is non-thermal, but not a simple power law.

• Appears displaced from host galaxy center of light.

• Inconsistent with AGN.
Summary

- Localized FRB 121102, to ~15 milliarcsec precision.
- Persistent, variable radio counterpart.
- Host is a dwarf galaxy at z~0.193.

Not yet addressed:

- Mechanism of the bursts. Magnetar models? AGN models?
- How typical is FRB 121102?
  
  Do all FRBs repeat? Or are there multiple classes of FRBs?