STARE: Fast Radio Bursts in the Local Universe

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Purpose

• Search for galactic versions of fast radio bursts (FRBs)
• Investigate the luminosity function of FRBs
  • How far down does the luminosity function extend?
• Perform a census of FRB progenitors within 5 Mpc
• Probe the gap between pulsar giant pulses and FRBs
Fast Radio Bursts

Pietka et al. 2015
The Luminosity of Galactic FRBs
Fix: All-sky rate of FRBs > 1 Jy ms

Infer: Volumetric rate of FRBs
The Luminosity of Galactic FRBs

Assume:

• FRBs track stellar mass
  Volumetric Rate $\propto M_{\text{stars}}$

• FRBs track star formation
  Volumetric Rate $\propto \text{SFR}$

OR

to infer an FRB rate \((L > 4\pi \text{ Jy ms } d_{\text{FRB}}^2)\) for an individual galaxy
The Luminosity of Galactic FRBs

• Have: galactic rate of FRBs > 4π Jy ms d_{FRB}^2
• Want: Luminosity of FRB that happens every year
• Extrapolate down the luminosity function until the galactic rate of FRBs is > 1 FRB yr^{-1}

Nicholl et al. 2017
The Repeater

- ~5000 FRBs sky$^{-1}$ day$^{-1}$ (Vedantham et al. 2016)
- $d_{\text{FRB}} = 817$ Mpc
- Volumetric rate = $8 \times 10^5$ FRBs yr$^{-1}$ Gpc$^3$
- FRBs track SFR: 0.02 FRBs yr$^{-1}$ MW$^{-1}$
- FRBs track $M_{\text{stars}}$: 0.04 FRBs yr$^{-1}$ MW$^{-1}$
- $\frac{dN}{dL} \propto L^{-1.6}$ (Nicholl et al. 2017)
- $L_{\text{yearly FRB}} = 0.002$ Jy ms Gpc$^2$
- Fluence at 10 kpc: 1.5 MJy ms
What if we change the luminosity function?

The Repeater:

- $\frac{dN}{dL} \propto L^{-1.6}$ & $d_{\text{FRB}} = 817$ Mpc
- Fluence at 10 kpc: 1.5 MJy ms

Some other FRB population:

- $\frac{dN}{dL} \propto L^{-2.0}$ & $d_{\text{FRB}} = 817$ Mpc
- Fluence at 10 kpc: 18 MJy ms

Any detection/nondetection is a strong probe of the FRB luminosity function!
How Bright are FRBs are in the Galaxy?
A census of nearby FRB progenitors

• We could see a typical 1 Jy ms FRB if it was < 5 Mpc away
• 5000 FRBs sky\(^{-1}\) day\(^{-1}\) = \(n_{\text{FRB}}V_{\text{Volume}}r_{\text{repetition rate}}\)
• Volume ~ 30 Gpc\(^3\) (z\sim0.5)
• Repetition Rate ~ 1/day (From repeater)
• Distance between FRB progenitors: ~110 Mpc
• Constrain:
  • Is the repeater unusually active?
  • What is the number density of FRB progenitors?
Previous Experiment: STARE

- Three crossed dipoles in a cavity
- Operated between 609-613 MHz
- Filtered RFI by coincidence
- Time resolution of 0.125 s
- Detection threshold of 27 kJy
- Only found solar transients
Implementation & Timeline
Design

• Three low gain, large field of view feeds at different locations
• Filter RFI by coincidence
• Detection criteria:
  • Same time
  • Same DM
  • Same RM in all 3 antennas
• Localization to < 30”
Design

- Operates between 1.28-1.53 GHz
- 2048 channels, 122 kHz resolution
- 131 microsecond time resolution
- Field of view: ~1.8 steradians
- SEFD ~7.4 MJy ($T_{sys} = 55$ K)
- $S/N = 7.3$ for 1 ms pulse $\Rightarrow S > 140$ kJy
Status

OVRO
- Operational
- Build first system
- Write software
- Operate at site

Palomar
- First light in 2 weeks!
- Build system
- Operate at site

Unit #3
- Goal: mid-2018
- Build third system
- Operate at site

Done!
Done!
Done!
In Progress
Peryton Detected!
Conclusion

• STARE will:
  • Search for FRBs in the Milky Way
  • Investigate the luminosity function of FRBs
  • Catch FRB progenitors in the Local Group
  • Probe the gap between pulsar giant pulses and FRBs

• There may be more FRBs in the galaxy than we think!

• Operational by mid-2018