Fast Radio Bursts

CHIME/FRB

Capabilities
Current Status
Recent Results

Synergies
Very short (~ms), very bright (~Jansky), radio bursts from ~Gpc away

Energies of $\sim 10^{38-39}$ erg
Luminosities $\sim 10^{41}$ ergs/s
(wimpy compared to other transients)

Similar to pulsar signals
(but not periodic, almost all single)

Rate $\sim 10^3$ /sky/day
at 1 Jy (Lawrence+2017, ++)  
(See frbcat.org; Petroff+ 2017)

~40 reported since 2007
Key questions

What are FRBs?
Are there multiple populations?

How do they link to other transients?

Can we use them as cosmological probes?
FAST RADIO BURSTS

- Origins are unclear — plenty of models but few constraints
  - Magnetars, pulsars, BNS mergers, NS-BH mergers...

- Need localization, multiwavelength follow-up
  - No counterparts, afterglows yet
    - sGRBs, GW, kilonovae, MW bursts possible
  - One FRB localized (Chatterjee+2017, Tendulkar+2017)

- Promising probes
  - Baryon distributions (Masui & Siggurdson 2015)
  - Magnetic fields (Akahori+ 2017)
  - MACHO dark matter, PBH binaries (Wang & Wang 2018)
FAST RADIO BURSTS

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Need a large homogenous complete sample of FRBs
Separate intrinsic properties and propagation

- Baryon distributions (Masui & Siggurdson 2015)
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Canadian Hydrogen Intensity Mapping Experiment

Transit telescope designed to study Baryon Acoustic Oscillations at $z=0.8–2.5$

Four 20m x 100m North-South cylinders

256 dual-pol feeds on each cylinder

400-800 MHz bandwidth

FOV: E-W $\sim2.5^\circ–1.3^\circ$, N-S $\sim120^\circ$

$\sim250$ sq deg

Parkes: 0.6 sq deg

Arecibo: 0.02 sq deg

CFI funded FRB backend for real-time detection: CHIME/FRB
1 – 10 FRBs per day at 10-sigma

Uncertainty due to spectral distribution etc.

Frequency band where no FRBs existed

Work by Pragya Chawla (Chawla+2017)
# FRBS AND CHIME

<table>
<thead>
<tr>
<th>What we want</th>
<th>Can CHIME deliver?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thousands of events for event rate, flux distribution, angular distribution, DM distribution, scattering vs DM, ...</td>
<td>Yes Fluix, spectra corrected for beam sensitivity</td>
</tr>
<tr>
<td>Find Repeaters</td>
<td>Yes</td>
</tr>
<tr>
<td>Real-time triggers</td>
<td>Yes ➔ GCN, VO, ATel Digest</td>
</tr>
<tr>
<td>Sensitivity to polzn vs freq, vs time</td>
<td>Yes</td>
</tr>
<tr>
<td>Localization:</td>
<td><strong>Arcminutes</strong> Within CHIME (SNR dependent)</td>
</tr>
<tr>
<td>Absolutely necessary for distinguishing models</td>
<td><strong>Arcseconds</strong>: Maybe, if optical/X-ray bursts/afterglows exist* OR VLBI</td>
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CHIME

Analog signal chain

Digitizers + FPGAs

GPU correlator

256 feeds

F-Engine

F-Engine

~ 13 Tbps

E & W Receiver Huts

N & S GPU Huts

1024 freq channels

x² visibilities

30 sec

CHIME Cosmology

16k freq channels

1024 stationary intensity beams

1-ms sampling

CHIME-FRB

1024 freq channels

10 tracking voltage beams

2.5-us sampling

CHIME-Pulsar

130 Gbps

256 feeds

2.5-us sampling

1024 freq channels

10 tracking voltage beams

2.5-us sampling

130 Gbps
**Key challenge:**

- **Process 13 Tbps data**
- Clean, real time RFI removal


Wide Field Astronomy

10/26/18
FIRST FRB

FRB 180725A
First FRB detection lower than 700 MHz
Others going all the way to 400 MHz
DM = 849.19 pc cm\(^{-3}\) (DM\(_{\text{gal}}\) = 70 pc cm\(^{-3}\) )

Time span = 256 ms

DM = 316.93 pc cm\(^{-3}\) (DM\(_{\text{gal}}\) = 80 pc cm\(^{-3}\) )

Time span = 256 ms

CHIME/FRB Collaboration

PRELIMINARY
Currently ‘pre’-commissioning and calibrating
Good up time in running 1000 beams on the sky, 24/7

CHIME Commissioning ➔ Full operation
Detect 360 – 3600 FRBs per year

Studying outriggers for CHIME/FRB
— Can we get milliarcsecond localization for every FRB?
SYNERGIES

- Associating FRBs to hosts
  - Arcsecond localization is challenging
  - Correlating FRB positions to galaxies, radio sources, other source types
  - Photo-z and spectroscopic surveys – SDSS, WFIRST, EUCLID, LSST

- Find prompt counterparts
  - In microwave bands with CMB experiments
  - Optical — rapid imaging, simul. observations
  - X-ray — simultaneous observations

- Afterglows
  - Search for faint optical, X-ray, GW transients — LSST, VLASS
Synergies

FRBs

Positions

VLA, CHIME/OT, SKA

Optical/X-ray facilities

1) Burst/Afterglow
2) Host galaxies

Multi-\(\lambda\) Follow up

Simul-observing

With other FRB searches

CHIME

Population

Theoretical Progress!

Counterparts / Afterglows

X-ray/Gamma-ray Facilities

LIGO
Stay tuned