Multiwavelength Constraints on the Nature of Fast Radio Bursts

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Abstract

The origin of Fast Radio Bursts (FRBs) is still unclear with a plethora of theoretical models for their origin. Several such models predict associated multi-wavelength emission, but previous searches for optical, X-ray or gamma-ray counterparts of FRBs have not led to any detections. The Galactic magnetar SGR 1935+2154A has been observed to simultaneously emit FRB-like bursts and X-ray flares. We present a joint radio/X-ray program using the eROSITA instrument and the Effelsberg and Parkes radio-telescopes to conduct simultaneous radio/X-ray observations of previously detected FRB positions. Low-DM and repeating FRBs make excellent targets for these coordinated observations aiming to observe coincident radio/X-ray flares to determine if this phenomenology applies to the extragalactic FRB population.ry-high-energy (VHE) emitting blazars, which are often faint radio sources.

2007 — **2014** — **2020**

Fast Radio Bursts

In 2007, the first FRB was detected by Lorimer et al. These millisecond-duration radio bursts are very intriguing since they release a massive amount of energy in a very short amount of time. Their exact origin is still unclear with several theoretical models that have been proposed. They are distributed isotropically across the sky and usually exhibit high (extragalactic) dispersion measures (DMs).

FRB Repeaters

In 2014, the detection of the first repeating FRB was made public by Spitler et al. After extensive follow-up campaigns by e.g., CHIME, ATCA, UTMOST etc. we now know of 22 repeating FRB sources. Most of them have been detected by the CHIME Collaboration et al. (2021) just recently.

The Galactic Magnetar

In 2020, astronomers first suceeded in detecting an **X-ray burst** in temporal coincidence with a bright FRB-like signal from the Galactic magnetar SGR 1935+2154. (Tavani et al., 2021; Mereghetti et al., 2020). This detection strongly supports models based on magnetars for extragalactic FRBs, which opens up a great detection potential of FRB-associated X-ray bursts for X-ray telescopes like eROSITA .

Program Idea

The eROSTIA eRASS survey performs eight all-sky scans within four years. This means that every position in the sky is observed twice a year for at least ~ 6 x 40 s - **including FRB positions!**

"Let's predict exact eROSITA passing times of previously known FRB positions and observe simultaneously with radio telescopes to get X-ray/radio coverage of FRBs!"

Sample Selection

Access to German eROSITA sky (gl>180°):
131 possible FRB targets

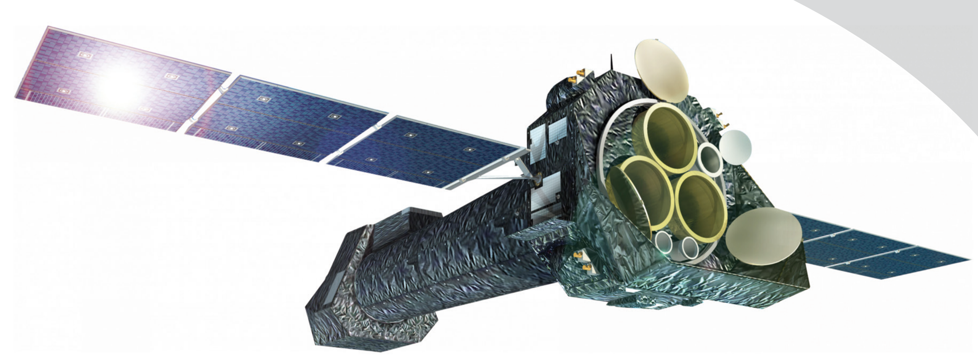
Once-Off FRBs:
– low-DM FRBs (< 200 pc cm^{-3})
– most likely closest FRBs
– 11 targets

Repeating FRBs:
– only 2 in German eROSITA sky

FRB Sample → eROSITA Orbit prediction

Effelsberg, Germany

Parkes, Australia



triggered up to 7 days in advance

Radio Observations
~30 min observing on FRB position while eROSITA is passing by

in case of a burst detection

X-ray follow-up (XMM-Newton)
Two pre-approved triggers for 80 ks each

Main Goal: Put unique constraints on theoretical models that predict FRB-associated X-ray emission

Only a small number of FRB repeaters has been targeted by occasional X-ray observations before. Moreover, there are virtually no FRBs detected previously during which X-ray coverage was available. This opens up a large detection potential for our program for simultaneous X-ray/radio data of FRBs.

Current Status

- ✓ Working eROSITA orbit prediction tool
- ✓ First Effelsberg observation on Jan 26, 2022
- ✓ Already collected ~150 s simultaneous X-ray/radio data
- × Observations currently paused due to eROSITA safe mode

Outlook

- ✓ Expected simultaneous X-ray/radio exposure up to 3.6 ks/year
- ✓ XMM-Newton follow-up FRB-search
- ✓ Search for X-ray transients in eROSITA data for all FRB pos.
- ✓ Extension to smaller telescopes and/or lower frequencies (e.g. LOFAR)