A SEARCH FOR PERSISTENT RADIO EMISSION TOWARDS THREE LOCALISED FAST RADIO BURST POSITIONS

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Abstract

The identification of persistent radio sources (PRSs) associated with Fast Radio Bursts (FRBs) provides valuable insights into their evolution, energetics, and formation mechanisms. Using data from successful MeerKAT Open Time Proposals, we detected candidate PRSs linked to several FRBs. Here, we present two detected candidate PRSs using MeerKAT data and one non-detection. Both FRB20221106A and FRB20181112A were found to have a host galaxy in the optical band, and whether the detected radio continuum emission comes from the host galaxy or PRS is still an open question. High-resolution observations from a telescope such as e-MERLIN are required to resolve this question. Lastly, in the case of FRB220190102, which was observed over two epochs, no radio continuum emission was detected. However, a flux upper limit is provided for both epochs.

1. Introduction

Fast radio bursts (FRBs) are short-duration (milliseconds) and energetic (up to 10^{43} erg) radio pulses coming from cosmological distances; see, e.g., Petroff et al. (2022) for a recent review. Since their discovery in 2007, FRBs have intrigued astronomers with their extraordinary luminosity and mysterious origins. Initially, FRBs were thought to be one-off events until the first repeating FRB was identified by Spitler et al. (2016), revealing that FRBs can be classified into two types: repeating and non-repeating.

The discovery of repeating FRBs has enabled astronomers to precisely localise some of them, such as FRB20121102A (Chatterjee et al., 2017) and FRB20190520B (Niu et al., 2022). These localised sources have revealed that certain repeating FRBs are associated with persistent radio sources (PRSs) in their surrounding environments. This connection has led to the hypothesis that FRBs may originate from highly energetic astrophysical environments, such as active galactic nuclei, young magnetars, or supernova remnants (Yang et al., 2020). The presence of PRSs around FRBs suggests that these bursts may be associated with specific types of sources, potentially providing insights into the environments that produce these powerful radio phenomena.

Three FRBs, namely FRB20181112, FRB20190102, and FRB20221106, form part of this work. FRB20181112A and FRB20190102A show dispersion measures (DMs) of 589.27 pc cm^{-3} and 363.6 pc cm^{-3}, with corresponding redshifts of $z = 0.4755$ and $z = 0.291$, respectively (Heintz et al., 2020). Both FRB20181112 and FRB20190102 are non-repeating FRBs that have significantly contributed to the Macquart relation and cosmological constraints (Macquart et al., 2020). Lastly, we include FRB20221106, which remains one of the least studied FRBs.

2. Data Reduction

We processed data obtained from the following Open Time proposals: SCI-20210212-CV-01, SCI-20220822-CV-01, and SCI-20230907-CV-01. We used the Oxkat pipeline and IDIA ilifu cluster. The Oxkat pipeline, developed by Heywood (2020), uses publicly available radio interferometric data reduction software to generate calibrated visibility data, continuum images, and diagnostic plots. The processing steps include flagging, cross-calibration, imaging and deconvolution, self-calibration, and finally, flux density measurements. Flux densities in the final images were determined using CASA's imfit task.

3.1 Results: detections

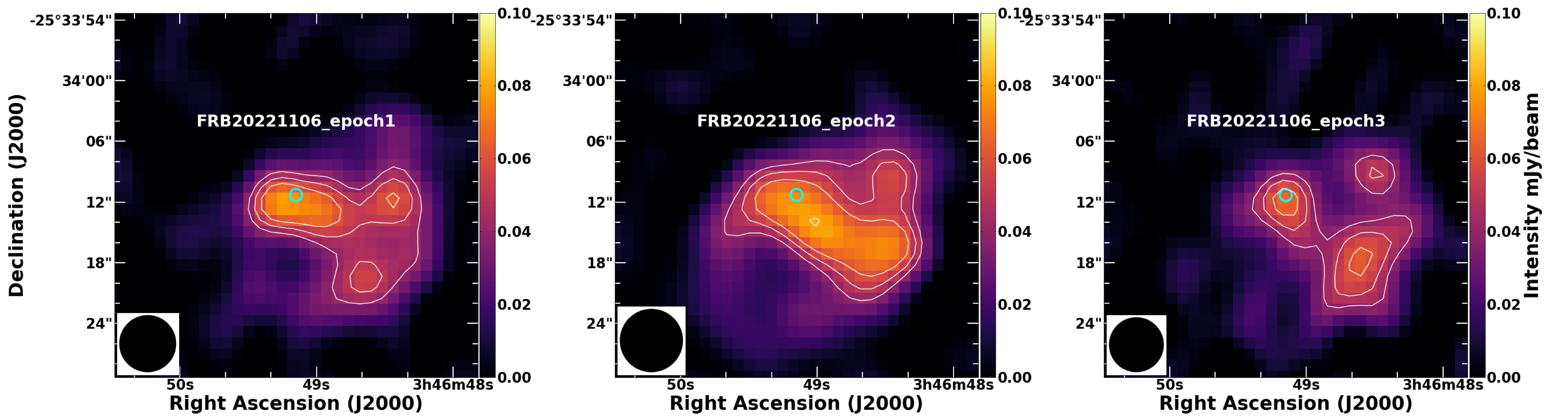

Figure 1: MeerKAT image of the FRB20221106 position, with the green circle indicating the $\sim 1''$ localisation uncertainty obtained using ASKAP (Shannon et al., 2025). The black ellipse in the bottom left corner represents the beam size of MeerKAT, and the positional uncertainty of the detected radio source is $\sim 0.3''$, which is smaller than the beam size. The white contours indicate continuum radio emission that coincides with the FRB position, represented at 3, 9, and 12 times the image's root-mean-square (RMS).

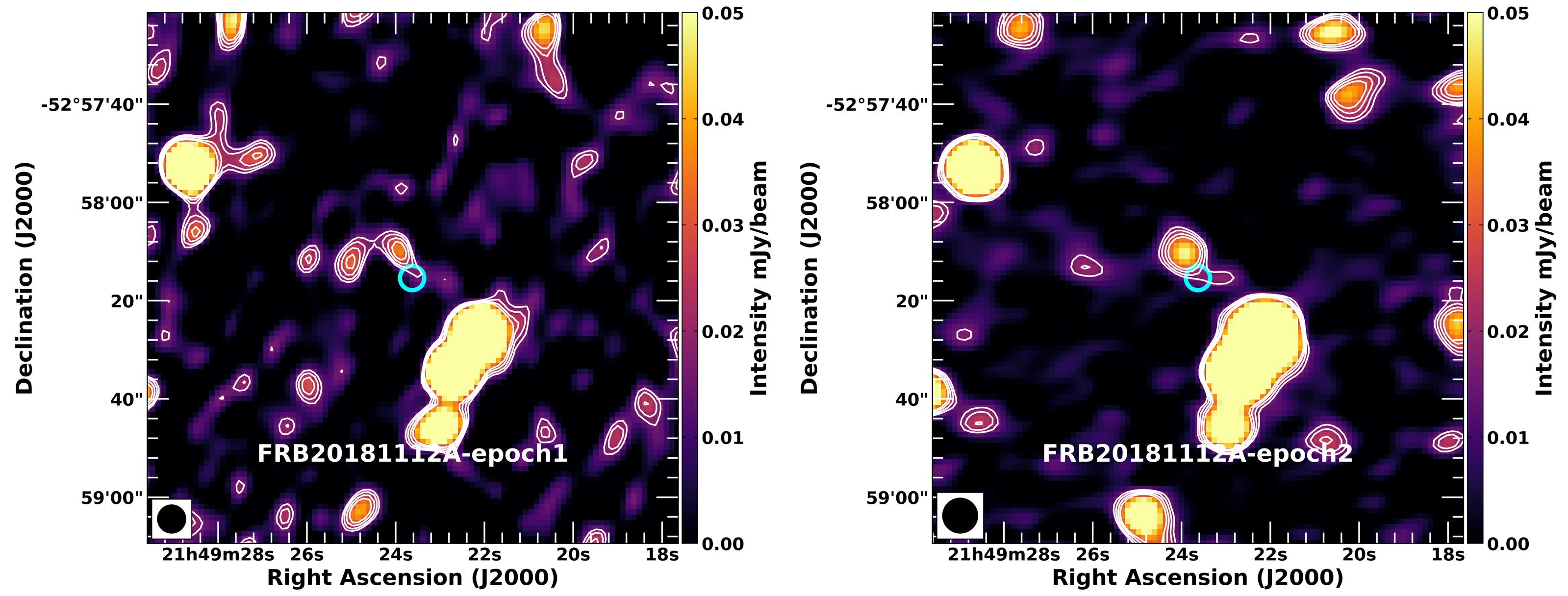

Figure 2: Same as in Figure 1, but for FRB20181112, observed during two different epochs with $\sim 0.5''$ uncertainty in the FRB position (Prochaska et al., 2019). The uncertainty in the position of the detected radio source is once again smaller than the beam. Although the emission is faint and extended, the FRB position lies well within the detected source extent.

3.2 Results: non-detections

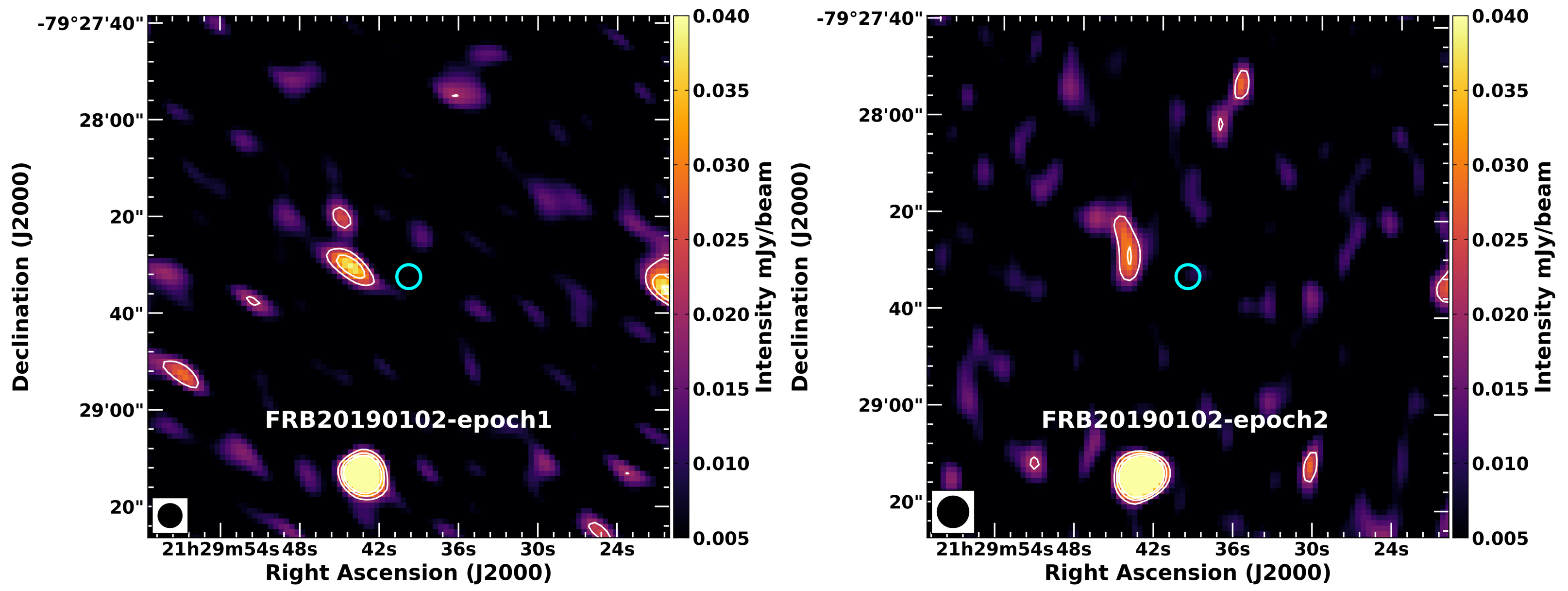

Figure 3: Same as in Figure 2, but for FRB20190102, observed during two different epochs with $\sim 0.5''$ uncertainty in the FRB position (Prochaska et al., 2019).

4. Discussions and Conclusions

Out of the three FRB positions, we have two detections and one non-detection. For FRB20221106, we have positive detections for observations during three epochs. The position of FRB20221106 coincides with a galaxy; whether the detected radio source originates from the PRS or the galaxy remains to be seen. In the case of FRB20181112, a telescope with high angular resolution is also needed to elucidate whether the host galaxy is responsible for providing the radio emissions, or if the emissions come from the PRS. Lastly, for FRB20190102, a flux upper limit was provided.

Paper Link

Figure 4: A QR code for our paper.

5. References

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