Absence of Bursts between 4 and 8 GHz from FRB 20200120E Located in an M81 Globular Cluster

Vishal Gajjar[1], Daniele Michilli[2,3], Jakob T. Faber[1,4], Sabrina Berger[2,3], Steve Croft[1,5], Aaron B. Pearlman[10,11,2,3,6], Ketan R. Sand[2,3], Paul Scholz[7], and Andrew P. V. Siemion[1,5,8,9]

Research Notes of the AAS, Volume 5, Number 7

Citation Vishal Gajjar *et al* 2021 *Res. Notes AAS* **5** 166

vishalg@berkeley.edu

[1] Department of Astronomy, University of California Berkeley, Berkeley, CA, USA; vishalg@berkeley.edu

[2] Department of Physics, McGill University, 3600 rue University, Montréal, QC H3A 2T8, Canada

[3] McGill Space Institute, McGill University, 3550 rue University, Montréal, QC H3A 2A7, Canada

[4] Department of Physics and Astronomy, Oberlin College, Oberlin, OH, USA

[5] SETI Institute, Mountain View, CA, USA

[6] Division of Physics, Mathematics, and Astronomy, California Institute of Technology, Pasadena, CA 91125, USA

[7] Dunlap Institute for Astronomy & Astrophysics, University of Toronto, 50 St. George Street, Toronto, ON M5S 3H4, Canada

[8] Jodrell Bank Centre for Astrophysics, Department of Physics & Astronomy, Alan Turing Building, The University of Manchester, M13 9PL, UK

[9] University of Malta, Institute of Space Sciences and Astronomy, Malta

[10] McGill Space Institute Fellow.

[11] FRQNT Postdoctoral Fellow.

Vishal Gajjar https://orcid.org/0000-0002-8604-106X

Daniele Michilli https://orcid.org/0000-0002-2551-7554

Jakob T. Faber https://orcid.org/0000-0001-9855-5781

Sabrina Berger https://orcid.org/0000-0002-4064-7883

Steve Croft https://orcid.org/0000-0003-4823-129X

Aaron B. Pearlman https://orcid.org/0000-0002-8912-0732

Paul Scholz https://orcid.org/0000-0002-7374-7119

Received July 2021
Accepted July 2021
Published July 2021

https://doi.org/10.3847/2515-5172/ac157a

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Abstract

We report the non-detection of dispersed bursts between 4 and 8GHz from 2.5 hr of observations of FRB20200120E at 6GHz using the Robert C. Byrd Green Bank Telescope. Our fluence limits are several times lower than the average burst fluences reported at 600 and 1400MHz. We conclude that these non-detections are either due to high-frequency bursts being weaker and/or scintillation-induced modulated. It is also likely that our observations were non-concurrent with any activity window of FRB20200120E.

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1. Introduction

Fast radio bursts (FRBs) are millisecond-duration pulses of extragalactic origin. FRB121102A has been detected across a wide frequency range, from 400MHz (Josephy et al. 2019) to 8 GHz (Gajjar et al. 2018), giving insights into the burst emission properties (Michilli et al. 2018); no other FRB has been detected across such a large range of frequencies. The newly discovered FRB20200120E was found to have a dispersion measure (DM) of 87.8pc cm^{-3}, which is the lowest reported among all FRBs (Bhardwaj et al. 2021). Recently, Kirsten et al. (2021) announced a precise localization of three bursts from FRB20200120E coinciding with a globular cluster in the M81 system. Thus, FRB20200120E provides an excellent opportunity to conduct deep observations at higher frequencies (>4 GHz). A detection at higher frequencies would offer the opportunity to (a) compare frequency-dependent burst rates, (b) measure scatter-independent rotation measure and polarization position angle, and (c) investigate frequency-dependent burst widths, sub-burst components, and downward-drifting behavior. Here, we report observations of FRB20200120E from the Green Bank Telescope (GBT), using the *C*-band receiver at 4–8GHz.

2. Observations and Analysis

We have an ongoing observing campaign with the GBT to trigger *C*-band observations for any repeating FRB reported by the CHIME/FRB project [12] with localization uncertainty smaller than the GBT beam (2$'$.5). The observations of FRB20200120E were taken for 2.5hr. We utilized the Breakthrough Listen (BL) backend, which is a state-of-the-art 64-node GPU cluster (MacMahon et al. 2018), deployed primarily to conduct the most comprehensive search for evidence of intelligent life in the universe (Worden et al. 2017). Recorded baseband voltages were converted to SIGPROC-formatted filterbank files (Lebofsky et al. 2019). As FRBs are known to show limited spectral coverage (Gajjar et al. 2018; Zhang et al. 2018), we divided our 4GHz band into eight 500MHz wide sub-bands, searched independently to improve the chance of detecting spectrally limited bursts (Faber et al. 2021). We used SPANDAK, a similar search pipeline to that described by Gajjar et al. (2018), to blindly search for single pulses, with search parameters listed in Table 1.

Table 1. Summary of Observations and Single Pulse Searches of FRB20200120E Across 4–8GHz

Observations and Search Parameters			
Source Name	FRB20200120E	DM_{range}	0–1000 pc cm^{-3}
R.A.(J2000)	$09^{h}57^{m}56\overset{''}{.}7$	Widths	0.3–76 ms
Decl.(J2000)	$+68°49'31\overset{''}{.}8$	S/N	>10
Frequency	4–8GHz	F_{UL} full band	35mJy ms
$T_{sampling}$	~350μs	$F_{UL}^{sub-band}$ ($\Delta\nu$~500 MHz)	100mJy ms
Obs. MJD (59259+)	0.969687500–1.072951388	burst-rate$_{UL}$	<0.4 hr^{-1}

Note. The $F_{UL}^{full\ band}$ and $F_{UL}^{sub\text{-}band}$ stand for minimum detectable fluence assuming a 1ms wide top-hat burst for the full band and any one of the sub-bands, respectively.

3. Results and Conclusion

We did not detect any significant dispersed burst across the full band (4–8 GHz) nor in any of the eight sub-bands. Upper limits on the fluences are listed in Table 1. Bhardwaj et al. (2021) reported an average burst fluence ~2210 mJy ms at 600MHz. Kirsten et al. (2021) reported multiple bursts at 1.4GHz with an average burst fluence ~500mJy ms and burst rate ~0.68 hr^{-1}. These fluences and burst rates are higher than our current fluence limits and our inferred burst rate. However, it is plausible that bursts at 6GHz are intrinsically weaker (or absent) than those detected at lower frequencies. Nimmo et al. (2021) and Majid et al. (2021) reported that bursts from FRB20200120E exhibit sub-burst structure at <100 ns scales, similar to "nanoshots" seen in giant pulses (GPs) from the Crab pulsar. Hankins (2000) compared simultaneous detections of several hundred GPs from the Crab pulsar at 1.4 and 5GHz and found the average instantaneous spectral index to be steep (α~−2). If the bursts from FRB 20200120E are indeed similar to GPs from the Crab pulsar, such a steep spectrum would render burst fluences at 6GHz below our detection threshold. Furthermore, the expected diffractive scintillation bandwidth varies from 200MHz to 3.5GHz across our observed band toward the source (see Majid et al. 2021). If the bursts are spectrally narrower than this scintillation bandwidth then they are likely to be 100% modulated, which could yield non-detections. It is also possible that FRB20200120E exhibits enhanced burst activity windows (seen from other repeating FRBs; Price et al. 2018; Zhang et al. 2018) and our observations were non-concurrent with such active phases. However, in the absence of any other reported non-detection, we are unable to verify if FRB20200120E indeed exhibits such prolonged inactive phases. Future simultaneous multi-frequency multi-epoch observations may provide insights into the burst properties around 6GHz.

Breakthrough Listen is managed by the Breakthrough Initiatives, sponsored by the Breakthrough Prize Foundation. The Green Bank Observatory is a facility of the National Science Foundation, operated under cooperative agreement by Associated Universities, Inc. J.T.F. and S.C. were supported by the National Science Foundation under grant No. 1950897.

Footnotes

12 https://www.chime-frb.ca/repeaters

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