



# Follow-up Observations of Apparently One-off Sources from the Parkes Telescope

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## Abstract

A small fraction of fast radio bursts (FRBs) have been observed with multiple bursts, whereas most Galactic sources emitting radio pulses are known to repeat. Here we present the results of follow-up observations of two FRBs and four rotating radio transients (RRATs). Among these, only one RRAT has been observed with repeating pulses, with an estimated period of around 1.297047 s. For comparison, we reanalysed the Parkes archival follow-up observations in CSIRO's data archive for all apparently one-off sources discovered by the Parkes telescopes, including 13 RRATs and 29 FRBs. In total, 3 RRATs are suggested to be repeaters, but no repeating signals were detected from the other sources. Reporting details of the nondetection observations for the apparently one-off sources would help investigate their origins, and catastrophic scenarios are worth proposing for both extragalactic and Galactic sources.

*Unified Astronomy Thesaurus concepts:* [Radio bursts \(1339\)](#); [Radio transient sources \(2008\)](#); [Radio pulsars \(1353\)](#)

## 1. Introduction

Before a population of fast radio bursts (FRBs) was reported (D. Thornton et al. 2013), sources emitting radio pulses were generally thought to be repeating (M. A. McLaughlin et al. 2006), and in principle, a transient was normally considered a convincing astrophysical source only when it had been detected in at least two observations (D. R. Lorimer & M. Kramer 2004). This trend led to a long debate about the astrophysical origin of the “Lorimer burst” (D. R. Lorimer et al. 2007; S. Burke-Spolaor et al. 2011; E. F. Keane et al. 2012; K. W. Bannister & G. J. Madsen 2014), in which no repeat pulse was detected in up to 90 hr of follow-up observations (D. R. Lorimer et al. 2024). However, D. Thornton et al. (2013) ended this debate, and worldwide FRB-hunting instruments (K. Masui et al. 2015; L. G. Spitler et al. 2016; R. M. Shannon et al. 2018), especially the Canadian Hydrogen Intensity Mapping Experiment (CHIME) telescope (CHIME/FRB Collaboration et al. 2021), have provided a large FRB sample including over 600 sources. This instantaneously changed the narrative of apparently one-off sources: although it is widely discussed whether all FRBs repeat, the fact is only around 10% of all currently known FRBs exhibit repeat bursts (CHIME/FRB Collaboration et al. 2023).

Besides the extragalactic source like FRBs, some apparently one-off Galactic sources were also discussed by E. F. Keane (2016): 12 sources labeled as rotating radio transients (RRATs) have never been observed to show repeating pulse, and the previous justification of astrophysical radio source (D. R. Lorimer & M. Kramer 2004) potentially leads to bias of the reported single-pulse Galactic events. However, it is notable that only the repeating sources could be proven to repeat, whereas one-off sources cannot be definitively classified. Therefore, for any apparently one-off source, it is important to present its detection significance and pulse

rate constraint, which are relatively lacking, especially for Galactic sources.

CSIRO's data archive<sup>4</sup> (G. Hobbs et al. 2011) provides the majority of publicly available Parkes high-time resolution data sets and is excellent for analyzing the results of follow-up observations of apparently one-off sources discovered by the Parkes telescope. The Parkes telescope dominated early FRB discoveries (D. R. Lorimer et al. 2007; E. F. Keane et al. 2012; D. Thornton et al. 2013; S. Burke-Spolaor & K. W. Bannister 2014; E. Petroff et al. 2015; V. Ravi et al. 2015; D. J. Champion et al. 2016; E. F. Keane et al. 2016; V. Ravi et al. 2016; E. Petroff et al. 2017) and has detected 30 FRB sources to date (S. Bhandari et al. 2018b, 2018a; S. Osłowski et al. 2019; E. Petroff et al. 2019; D. C. Price et al. 2019; S.-B. Zhang et al. 2019; S. B. Zhang et al. 2020). However, only one of these FRBs was observed to repeat through the highly sensitive Five-hundred-meter Aperture Spherical radio Telescope (FAST; R. Luo et al. 2020). Meanwhile, 13 RRATs discovered by Parkes were reported to be apparently one-off (S. Burke-Spolaor & M. Bailes 2010; S. Burke-Spolaor et al. 2011; E. F. Keane et al. 2011; S. B. Zhang et al. 2020).

In this paper, we present the results of our follow-up observations of the two FRBs and four RRATs we discovered from the Parkes archive (S.-B. Zhang et al. 2019; S. B. Zhang et al. 2020), as well as the publicly archival observations of other apparently one-off FRBs and RRATs discovered by Parkes. In Section 2, we describe the details of the observations and data reduction. The results from these data sets are presented in Section 3. We discuss the results and conclude in Section 4.

## 2. Observation and Data Reduction

We carried out follow-up observations using the Ultra-Wide-band Low (UWL) receiver (G. Hobbs et al. 2020) of the Parkes telescope for two FRBs, FRB 010305A and FRB 010312A, and four RRATs, SPC 000115 (hereafter J1328–58), SPC 000621 (hereafter J1605–45), SPC 001122 (hereafter J0808–32), and SPC 010208 (hereafter J1905–01). Our observing pointing followed the pointing centers of the detected beams (S.-B. Zhang

<sup>4</sup> CSIRO Data Access Portal (DAP): <https://data.csiro.au>.

et al. 2019; S. B. Zhang et al. 2020) of the Parkes Multibeam receiver system (L. Staveley-Smith et al. 1996). The UWL system covers frequencies from 704 to 4032 MHz. Data were recorded with two-bit sampling every 64  $\mu$ s in each of the 0.5 MHz wide frequency channels. Data were coherently dedispersed at the dispersion measures (DMs) of the initial detections ( $DM_{\text{det}}$ ), with only one polarization being recorded. However, when any source was observed to be repeating, full Stokes information was collected. A 2 minute noise diode signal was also recorded for polarization calibration before each observation. In total, we observed J1328–58 for 3.69 hr, J1605–45 for 0.99 hr, J0808–32 for 15.62 hr, J1905–01 for 0.75 hr, FRB 010305A for 9.87 hr, and FRB 010312A for 3.89 hr.<sup>5</sup> In addition to our observations, we also obtained archival observations with pointing within 7' ( $\sim 0.5 \times$  the half-power beamwidth of the Multibeam receiver system) of the pointing centers of the detected beams (hereafter referred to as follow-up observations) for 13 RRATs and 29 FRBs discovered by the Parkes telescope and reported as apparently one-off sources. Since all these events were detected by the Parkes Multibeam receiver system, we collected only the archival Multibeam data sets and UWL data sets; the latter were supposed to have higher sensitivity and a larger field of view (FOV) than the Multibeam data sets (G. Hobbs et al. 2020). Except for three sources that proved to be repeating (see details in Section 3.1), the details of the follow-up observations for other sources are listed in Table 1.

Data collected from the Multibeam and UWL receivers were processed using search pipelines based on the pulsar/FRB single-pulse searching package PRESTO (S. M. Ransom 2001). We processed the full band data from the Multibeam receiver following a well-used pipeline (S. B. Zhang et al. 2020) but divided the UWL data into a series of subbands ranging from 128 to 3328 MHz based on a tiered strategy (P. Kumar et al. 2021). Strong narrowband and short-duration broadband radio frequency interference (RFI) were identified and marked using the PRESTO routine RFIFIND. Data were then dedispersed in a range of DM values of  $DM_{\text{det}} \pm 20 \text{ pc cm}^{-3}$ , with a step of  $0.1 \text{ cm}^{-3}$ . Single-pulse candidates with signal-to-noise ratio (S/N) greater than 7 were recorded and visually inspected. To minimize the false positives caused by statistical noise fluctuations or structured RFI, a candidate was identified as a detected pulse only if it exhibited a plausible sweep in the dedispersed frequency–time plane. For Multibeam data, the candidate also had to be detected in no more than three adjacent beams. For the data with full Stokes information, the dedispersed polarization data were calibrated using the PSRCHIVE software package (A. W. Hotan et al. 2004; W. van Straten et al. 2012), with correction for differential gain and phase between the receivers achieved through the injection of a noise diode signal before each observation. Rotation measures (RMs) for all detected pulses were measured using the RMFIT program in the package PSRCHIVE (A. W. Hotan et al. 2004; W. van Straten et al. 2012), searching for a peak in the linearly polarized flux  $L = \sqrt{Q^2 + U^2}$ , within the RM range from  $-4000$  to

$4000 \text{ rad m}^2$  with a step of  $1 \text{ rad m}^2$ . RMFIT corrects for Faraday rotation for each trial RM, producing a total linear polarization profile and an RM spectrum. A Gaussian fit was then applied to determine the optimal RM along with its  $1\sigma$  uncertainty.

### 3. Results

#### 3.1. Repeating Sources

After reanalyzing the results of the 13 RRATs and 29 FRBs, we identified three RRATs, SPC 991113, J1709–43, and J0808–32, as likely repeating sources. Figure 1 presents examples of our detected repeating pulses from each of these three sources. Due to their similar DM and close positions, we suggest two of them, SPC 991113 and J1709–43, likely originate from the same sources as two other reported repeating sources, RRAT J1739–2521 (B. Y. Cui et al. 2017) and PSR J1709–4401 (S. D. Bates et al. 2012), respectively. Table 2 lists the properties of these previously reported one-off detections and their related repeating sources. The DMs of the related repeating sources are consistent with those of the one-off detections, and the differences in localization between the reported one-off detections and the related repeating sources are well within the localization uncertainties of the one-off detections.

From our 15.62 hr UWL observation of J0808–32 at the pointing (J2000) 08:08:10.6,  $-32:18:11.0$  (S. B. Zhang et al. 2020), we detected a total of 34 repeating single pulses, leading to a pulse rate of  $\sim 2.2 \text{ hr}^{-1}$ . By analyzing the greatest common divisor of the time intervals between the time of arrival (TOA) of the detected pulses, we identified a period of 1.297047(5)s by minimizing the variance of the expected TOA phases. However, no significant signal was observed from the periodic search pipeline using the PRESTO package (S. M. Ransom 2001; S.-B. Zhang et al. 2018), nor by manually folding each observation using the DSPSR package (W. van Straten & M. Bailes 2011) based on this derived period. The best estimate of the RM for the detected single pulses yielded a value of  $77.2(2) \text{ rad m}^{-2}$ . The Galactic longitude and latitude of J0808–32 are approximately  $245^\circ.0$  and  $0^\circ.2$ , respectively, and its DM of around  $127.2 \text{ pc cm}^{-3}$  indicates a relatively small distance of  $\sim 433 \text{ pc}$  using the YMW16 model (J. M. Yao et al. 2017) and  $\sim 1582 \text{ pc}$  using the NE2001 model (J. M. Cordes & T. J. W. Lazio 2002). More observations are encouraged to investigate this source further.

#### 3.2. Apparently One-off Sources

The details of our accessible archival follow-up observations of the other 10 RRATs and 29 FRBs are listed in Table 1. For 3 FRBs, FRB 110220A, FRB 110626A, and FRB 110703A, we did not find any archival data sets. As indicated in Table 1, we redetected the initial pulses for 7 RRATs and 8 FRBs and provided the precise pointing centers for the detected beams, S/N, and DMs from our processing. However, no repeating signals were detected from these data sets.

We presented the initial detection S/N versus the archival total observations for these apparently one-off RRATs and FRBs in the left panel of Figure 2. In principle, since our single-pulse search threshold is 7, a more significant initial detection and further follow-up observations would place more strict constraints on the source repeatability and indicate a “one-off” nature. From the total observations, the repeatability of the apparently one-off FRBs is better constrained, as most of them

<sup>5</sup> The observations were conducted as parts of several proposals focused on searching for repeating FRBs and RRATs, as well as during available green time of Parkes. The newly discovered repeating source J0808–32 (see Section 3.1) has been observed the longest. FRBs, which were prioritized in these proposals, and the J1328–58, which had the highest initial detected S/N among our targets, were allocated relatively long tracking times. Due to the limited total allocated observation time, the two one-off Galactic sources, J1605–45 and J1905–01, were only observed from about 1 hr each.

**Table 1**  
Parkes Public Archival Follow-up Observations of Apparently One-off RRATs and FRBs Discovered by the Parkes Telescopes

Name	Pointing R.A. (J2000)	Pointing Decl. (J2000)	$L_{\text{unc}}$ (')	S/N	DM (pc cm <sup>-3</sup> )	$T_1$ (hr)	$T_2$ (hr)	$T_{\text{tot}}$ (hr)	$D_{\text{det}}$ (MJD)	$D_{\text{ear}}$ (MJD)	$D_{\text{lat}}$ (MJD)
J0845–36*	08:45:07.2	−36:05:31.5	14	7.0	29(2)	1.75	0	1.75	52601	50993	55240
J0923–31	09:23:38.1	−31:57:17.8	14	9.0	72(20)	0.89	0	0.89	...	51197	55649
J1135–49	11:35:56	−49:25:31	14	~10	114(20)	0.77 <sup>R1</sup>	0	0.77 <sup>R1</sup>	...	...	...
J1311–59*	13:11:36.5	−59:19:12.3	14	10.6	149(4)	3.88	0	3.88	51467	51467	55108
J1328–58*	13:28:55.8	−58:54:05.9	14	19.4	213(2)	2.09	3.69	5.78	51558	51558	59195
J1541–42	15:41:55	−42:18:50	14	~10	60(10)	0.14 <sup>R1</sup>	0	0.14 <sup>R1</sup>	...	...	...
J1605–45*	16:05:35.7	−45:45:05.2	14	11.4	65(2)	0.83	0.99	1.82	51716	51716	59100
J1610–17*	16:10:24.2	−17:52:13.0	14	8.7	53(3)	1.56	0	1.56	52331	52331	57233
J1649–46*	16:49:47.8	−46:13:46.4	14	10.1	404(10)	3.68	0	3.68	51457	51457	59146
J1905–01*	19:05:49.0	−01:26:42.1	14	10.2	103(3)	0.88	0.75	1.63	51948	51948	59199
FRB 010125A*	19:06:53.0	−40:37:14.4	14	17.9	786.5(3)	0.23	0	0.23	51934	51934	56846
FRB 010305A*	04:57:19.5	−52:36:24.7	14	10.2	350(5)	0.07	9.87	9.94	51973	51973	59197
FRB 010312A*	05:26:54.9	−64:56:19.2	14	11.0	1163(20)	2.38	3.89	6.27	51980	51979	59123
FRB 010621A*	18:52:05.1	−08:29:35.0	14	15.8	749(10)	25.52	0	25.52	52081	52081	55659
FRB 010724A*	01:18:06.0	−75:12:18.7	14	32.0	373(3)	90 <sup>R2</sup>	0	90 <sup>R2</sup>	52114	52079	57650
FRB 090625A*	03:07:47.2	−29:55:35.9	14	25.2	899.6(1)	2.64	0	2.64	55007	55007	57327
FRB 110214A	01:21:17	−49:47:11	14	13	168.8(5)	30.32	0	30.32	55606	57188	57934
FRB 110220A	22:34:38	−12:23:45	14	49	944.38(5)	...	0	...	55612	...	...
FRB 110626A	21:03:43	−44:44:19	14	11	723(0.3)	...	0	...	55738	...	...
FRB 110703A	23:30:51	−02:52:24	14	16	1103.6(7)	...	0	...	55745	...	...
FRB 120127A	23:15:06	−18:25:38	14	11	553.3(3)	0.31	0	0.31	55953	57192	58125
FRB 121002A	18:14:47	−85:11:53	14	16	1629.18(2)	46.5	0	46.5	56202	52419	58560
FRB 130626A	16:27:06	−07:27:48	14	20	952.4(1)	0.23	0	0.23	56469	52457	57864
FRB 130628A	09:03:02	+03:26:16	14	29	469.88(1)	0.16	0	0.16	56471	57957	57957
FRB 130729A	13:41:21	−05:59:43	14	14	861(2)	11.17	0	11.17	56502	57913	58335
FRB 131104A	06:44:10	−51:16:40	14	30	779(1)	85.31 <sup>+R3</sup>	0	85.31 <sup>+R3</sup>	56600	52178	58330
FRB 140514A	22:34:06.2	−12:18:46.5	14	16	562.7(6)	27.64 <sup>+R4</sup>	0	27.64 <sup>+R4</sup>	56791	57327	58142
FRB 150215A	18:17:27	−04:54:15	14	19	1105.6(8)	10 <sup>R5</sup>	0	10 <sup>R5</sup>	57068	51256	55305
FRB 150418A	07:16:30.9	−19:02:24.4	14	39	776.2(5)	50.73 <sup>+R6</sup>	5.79	56.52 <sup>+R6</sup>	57130	52139	59178
FRB 150610A*	10:44:27.0	−40:05:23.2	14	16.9	1593.1(4)	16.93 <sup>+R7</sup>	1.50	18.43 <sup>+R7</sup>	57183	51931	58620
FRB 150807A	22:40:24.4	−53:15:46.8	1.8	50	266.5(1)	90 <sup>R8</sup>	0	90 <sup>R8</sup>	57241	54897	57867
FRB 151206A	19:21:25	−04:07:54	14	10	1909.8(6)	11.57 <sup>+R7</sup>	0	11.57 <sup>+R7</sup>	57362	51257	58560
FRB 151230A	09:40:50	−03:27:05	14	17	960.4(5)	37.16 <sup>+R7</sup>	0	37.16 <sup>+R7</sup>	57386	52256	58570
FRB 160102A	22:38:49	−30:10:50	14	16	2596.1(3)	27.00 <sup>+R7</sup>	0	27.00 <sup>+R7</sup>	57389	57734	58559
FRB 171209A	15:50:25	−46:10:20	14	35.8	1457.4(3)	3.53	0	3.53	58096	51063	59105
FRB 180309A	21:24:43.8	−33:58:44.5	14	112.8	263.42(1)	1.86	0	1.86	58186	51935	53308
FRB 180311A	21:31:33.4	−57:44:26.7	14	15.3	1570.9(5)	0.83	0	0.83	58188	54897	57204
FRB 180714A	17:46:12	−11:45:47	14	19.8	1467.9(3)	0.23	0	0.23	58313	51068	55059
FRB 180923B*	15:10:55.4	−14:06:10.2	14	13	548(3)	4.63	3.59	8.22	58384	58383	59870

**Note.** The columns are as follows: (1) RRAT names based on the J2000 coordinate and FRB names based on the initial detection date. \* indicates that the file containing the initial detection is publicly accessible on DAP, and the presented properties are derived through our reprocessing. (2, 3) J2000 R.A. and decl. of the pointing center for the detected beam. (4) The localization uncertainties in units of arcminutes. (5, 6) The S/N and DM of the initial detection. (7, 8, 9) The archival Parkes follow-up observations of Multibeam, UWL, and combined two (hereafter referred to as total observation). Notably, several large survey data sets are awaiting transfer and storage in DAP, and the current Parkes archive is incomplete. <sup>+</sup> indicates the value is the sum of the referred published follow-up observation and the archival observations later than its published time. They are <sup>R1</sup> (S. Burke-Spolaor et al. 2011) of 0.77 hr for J1135–49 and 0.14 hr for J1541–42, <sup>R2</sup> (D. R. Lorimer et al. 2024) of 90 hr, <sup>R3</sup> (V. Ravi et al. 2015) of 78 hr, <sup>R4</sup> (E. Petroff et al. 2015) of 14.7 hr, <sup>R5</sup> (E. Petroff et al. 2017) of 10 hr, <sup>R6</sup> (E. F. Keane et al. 2016) of 5.84 hr, <sup>R7</sup> (S. Bhandari et al. 2018b) of 10 hr for FRB 150610A, 3 hr for FRB 151206A, 9.2 hr for FRB 160102A, and <sup>R8</sup> (V. Ravi et al. 2016) of 90 hr. (10,11,12) Date of the initial detection; the earliest and latest observations are available in DAP.

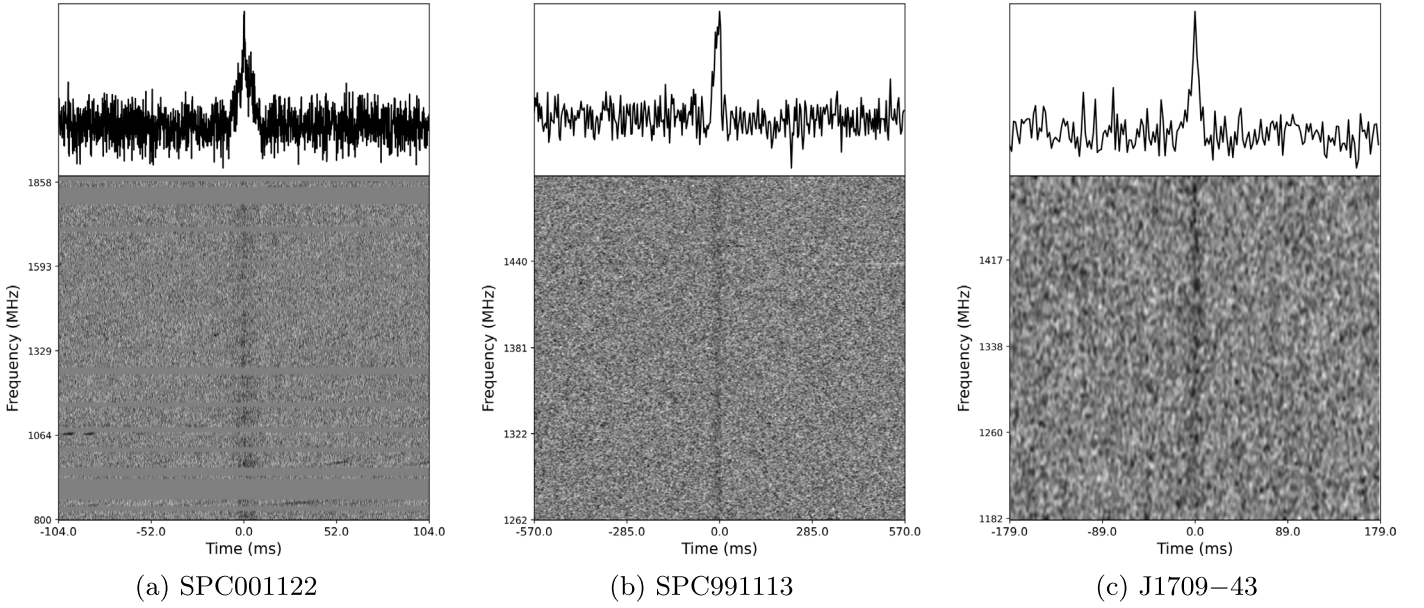
were detected with high S/N and follow-up observed with relatively sufficient time. In all, 1 RRAT, J1328–58, with the highest S/N of 19.4, compared to other RRATs with S/N up to 11.4, and also having the longest follow-up time of 5.78 hr among all RRATs, appears to be the most reliable one-off RRAT source. However, it is notable that some sources have not been adequately reobserved to constrain the detectability, with 3 RRATs and 6 FRBs observed for less than even 1 hr.

Higher-sensitivity follow-up observations are expected to detect fainter and more events from a repeating source. Based on the radiometer equation (D. R. Lorimer & M. Kramer 2004),

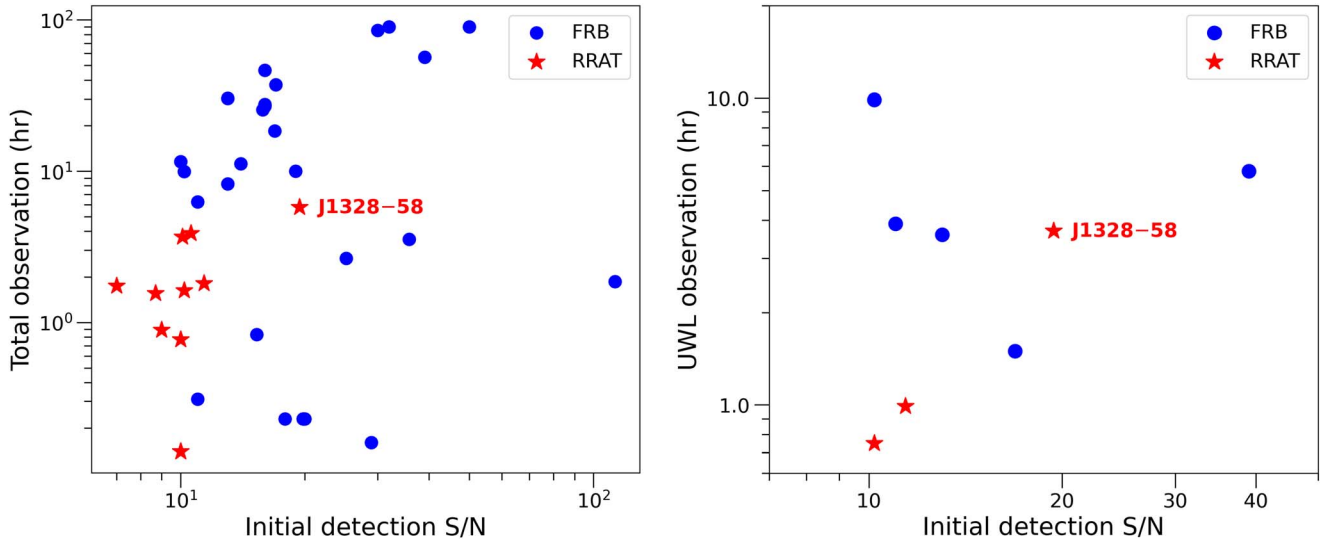
the sensitivity of the UWL observation is about 1.7<sup>6</sup> to 3.4<sup>7</sup> times of that of the Multibeam observation. Assuming a power-law energy distribution like the repeating FRBs (D. Li et al. 2021) and pulsar giant pulses (A. Bera & J. N. Chengalur 2019) with an index of  $\sim -3$ , the same length of UWL observation is expected to detect  $\sim 5$  to 39 times of the number of single pulses from the Multibeam observation. However, only 3 of the

<sup>6</sup> This considers the frequency range of 0.7–1.5 GHz, which fully covers the FOV of the Multibeam observation.

<sup>7</sup> This considers the full frequency range of the UWL receiver.



**Figure 1.** Profiles and dynamic spectra for examples of detected pulses from three repeating sources. The bursts are plotted after being dedispersed using DMs of  $127.2 \text{ pc cm}^{-3}$  for (a) J0808-32,  $186.4 \text{ pc cm}^{-3}$  for (b) SPC 991113, and  $225.8 \text{ pc cm}^{-3}$  for (c) J1709-43. (a) is the Parkes UWL data, while (b) and (c) are the Multibeam data.



**Figure 2.** The initial detection S/N vs. the archival total observations (left) and UWL observations (right). The FRBs and RRATs are represented by the blue circle and red star, respectively.

**Table 2**  
Properties of Three Repeating Sources

Name of One-off Detection	Pointing R.A. (J2000)	Pointing Decl. (J2000)	$L_{\text{unc}}$ (')	DM ( $\text{pc cm}^{-3}$ )	Name of Related Repeating Source	R.A. (J2000)	Decl. (J2000)	DM ( $\text{pc cm}^{-3}$ )	$L_{\text{diff}}$ (')
J0808-32	08:08:10.6	-32:18:11.0	14	136(10)	J0808-32	...	...	127.2(6)	...
SPC 991113	17:39:49.6	-25:13:16.2	14	203(26)	J1739-2521	17:39:32.83	-25:21:02	186.4	9.5
J1709-43	17:09:47	-43:54:43	14	228(20)	J1709-4401	17:09:41.39	-44:01:11.2	225.8(4)	6.5

**Note.** The columns are as follows: (1, 2, 3, 4, 5) Names, J2000 R.A. and decl., localization uncertainties, and DM of the reported one-off detections. (6, 7, 8, 9) Names, J2000 R.A. and decl., and DM of the related repeating sources. (10) The differences in localization between the reported one-off detections and the related repeating sources.

10 RRATs and 5 of the 29 FRBs have been observed by the Parkes UWL, as shown in the right panel of Figure 2. Among these 8 sources, the UWL observing lengths for 3 are around 1 hr, with the maximum UWL follow-up being less than 10 hr for FRB 010305A. Notably, RRAT J1328–58 still has the maximum UWL follow-up observations among these 3 RRATs.

#### 4. Discussion and Conclusions

Among the 13 reported apparently one-off RRATs discovered by the Parkes telescopes, our reanalysis suggests three of 3 are repeaters: 2 (SPC 991113 and J1709–43) are previously known sources (J1739–2521 and J1709–4401) and 1 (J0808–32) is a new repeater. This repeating fraction is larger than that of the 30 FRBs detected by Parkes, where only 1 (FRB 180301A) has been observed to repeat by the FAST telescopes (R. Luo et al. 2020). The Parkes UWL observation then also detected repeating pulses from this source (P. Kumar et al. 2023). As shown in Figure 2, even detected with larger S/N and followed by longer observations, FRBs are still harder to observe repeating signals. However, it is notable that many FRBs discovered by the Parkes telescope were still poorly followed, and only a few of them have been tracked with higher-sensitivity observations such as Parkes UWL. It is challenging to use single-dish telescopes to follow the apparently one-off sources detected by single dishes: the FOV of a larger telescope normally cannot well cover the initial detection’s localization, and a smaller telescope cannot provide sufficient sensitivity. Applying Parkes UWL to follow the apparently one-off sources detected by its Multibeam observations is efficient due to its higher sensitivity, and its FOV is larger than the localization uncertainties obtained by a single beam of the Multibeam receiver. Our new detection of repeating pulses from J0808–32 and the detection of repeating pulses from FRB 180301A by P. Kumar et al. (2023) have proved the feasibility of this approach. A better method would be to observe these sources using array telescopes such as MeerKAT (e.g., TRAPUM Survey; B. Stappers & M. Kramer 2016; Weiwei Chen et al. 2021), which has even higher sensitivity, larger FOV, and can precisely localize the source immediately after a repeating signal is detected.

Besides searching for repeating signals from those apparently one-off sources, it is also important to investigate why they appear to be one-off in current observations. FRBs have a large sample of apparently one-off sources (CHIME/FRB Collaboration et al. 2021), and many models have been proposed to explain them (E. Platts et al. 2019). However, the discussion of one-off Galactic radio pulses is lacking, and the relative sample size is potentially caused by the bias of the reported single-pulse Galactic events (D. R. Lorimer & M. Kramer 2004; E. F. Keane 2016). We have presented 10 Galactic radio events that are still one-off, including 1 source detected with a S/N of 19.4 that has been followed up with 5.78 hr of observations, including 3.69 hr of UWL time.

Several reasons could make a repeating Galactic source observed with only a single detection: (1) The initial observations have short durations, and the signals were affected by intense RFI or severe scintillation (S. Burke-Spolaor & M. Bailes 2010). (2) The source is extremely nulling and has a wide range of energy distribution, making only the very rare bright pulses detectable (S. B. Zhang et al. 2024). (3) The more frequent pulses are extremely faint and hard to detect, similar to the normal emission of pulsars with giant pulses (M. V. Popov

& V. A. Soglasnov 2006; M. Geyer et al. 2021), (4) some special RRATs (e.g., 1846–0257 and J1854+0306) exhibit extremely faint sequential emissions (S. B. Zhang et al. 2024), or (5) a magnetar like SGR J1935+2154 can generate frequent pulses during specific periods (W. Zhu et al. 2023). Scenario (1) could be well examined by more similar observations. Observations with higher sensitivity are efficient to test scenarios (2) and (3) and necessary to test scenarios (4) and (5). Since the higher sensitivity is compared to the sensitivity of the initial detection, well-localized apparently one-off sources detected by a relatively low-sensitive array telescope, such as the ASKAP telescope (K. W. Bannister et al. 2019; Z. Wang et al. 2024), would be excellent to follow up by other telescopes. The forthcoming Cryogenic Phased Array Feed receiver of the Parkes telescope could also provide a good chance to detect numerous apparently one-off sources. After a large sample of one-off RRATs is obtained and the details of nondetection observations of these sources are reported, catastrophic scenarios are worth proposing not only for extragalactic sources such as FRBs but also for Galactic sources. Such scenarios for close sources would be more practical to examine.

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