Long-Term Observations of Giant Radio Pulses with the Large Phased Array in the Pushchino Radio Astronomy Observatory

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Abstract. We present here results of our long-term observations of Giant Radio Pulses with Large Phased Array radio telescope at 111 MHz. Rates of the generation of single GRPs and groups of GPRs in successive pulsar pulses for 6 second period pulsars were analyzed. It was found that GPRs' rates and time distributions essentially differ for these pulsars. The correlation between glitches and the rate of GRPs from B0531+21 was not found.

Keywords: pulsars: individual: B0301+19, B0809+74, B0950+08, B1112+50, B1133+16, B1237+25

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1 Introduction

The emission of giant radio pulses (hereinafter GRPs) is one of several mysterious phenomena of modern pulsars' astrophysics. It is expressed through dramatic increase of the peak flux density and the fluence of individual pulses from a pulsar. For the first time, this phenomenon was discovered in the Crab pulsar (B0531+21) in Sutton et al. (1971). Later, the similar pulses were discovered from millisecond pulsar B1937+21 (Wolszczan et al. 1984). Later on GRPs were discovered from a number of other pulsars by Singal (2001); Ershov & Kuzmin (2003); Johnston & Romani (2003); Kuzmin & Ershov (2004); Joshi et al. (2004); Knight & et al. (2005); Kuzmin & Ershov (2006); Crawford et al. (2013). Among

the pulsars with GRPs there are objects with essentially different physical characteristics. This fact makes the theoretical description of the mechanism of GRPs generations more complicated.

Starting with 2011, the observational program to find pulsars with GRPs is being implemented in Pushchino Radio Astronomy Observatory of the Astro Space Center of P.N. Lebedev Physical Institute. As a result, the program has led to a discovery of GRPs from PSR B1237+25 and B0301+19 (Kazantsev & Potapov 2017, 2018; Kazantsev et al. 2019), and brought rich statistical results on the behavior of GPRs over long time intervals.

2 Observations

All observational data were obtained with The Large Phased Array of Pushchino Radio Astronomy Observatory (LPA LPI). This radio telescope is a transit radio telescope thus the duration of observations depends on the declination of an observing pulsar. The duration of one observation was around 3 minutes for pulsars with a low declination and to 11 minutes for these with a high declination. The central frequency of observations was equal to 111 MHz. The effective bandwidth was equal to 2.3 MHz. During our observation sessions, the telescope effective area was 20 000±1300 m^2 in the zenith direction. One linear polarization was used.

3 Discussion and Results

3.1 Second-Period Pulsars

Among the pulsars with GRPs we selected the following group of second-period pulsars (B0301+16, B0809+74, B0950+08, B1112+50, B1133+16, B1237+25) for more detailed analysis. These pulsars have very similar physical parameters such as period, its derivative of the period, the magnetic field at the light cylinder etc.). Thus one can expect that the patterns of GRPs emission are very close as well.

We analyzed the rate of GRPs generation and clustered GRPs generation. Unexpectedly, the different pulsars behaved completely different. The pulsar B1112+50 demonstrates rather stable rate of GRPs generation. At the same time, the pulsar regularly emits GRPs in pairs.

The other studied pulsars with GRPs have demonstrated much more unstable generation rate. There were months without a single detected GRP. Also the cases of pair GRPs from these pulsars are rare and isolated.

The detailed results of the investigation are published in the preprint of an article by Kazantsev & Basalaeva (2020).

3.2 Crab Pulsar

The analysis of the rate of GRPs generation from B0531+21 was performed separately. The pulsar demonstrates a regular jumps of the period (glitches). It is an extremely dramatic phenomenon which can significantly impact the pulsar magnetosphere (Haskell & Melatos 2015). Around 2017 November 08 (MJD=58064) the largest glitch in almost 50 years of observations of B0531+21 was detected (Shaw et al. 2018). The relative increase in frequency was $\delta\nu/\nu = 520 \times 10^{-9}$. However, according to our analysis of the rate of GRPs generation from B0531+21, there was no significant correlation between glitches and the rate. For the Crab pulsar the rate is quite unstable and demonstrates quiet and active periods. The maximums and minimums of the rate of GRPs generation do not match with the dates of observed glitches (Shaw 2020). Nevertheless we have discovered an anomalous growth of the monthly averaged rate of GPRs with fluence over 50000 Jy ms at near MJD 58200. The rate is about an order of magnitude greater than the largest one observed in the previous 9 years. Possible connection between anomalous glitch and anomalous GPRs' rate needs further detailed investigation.

The results are published in the preprint of an article by Kazantsev et al. (2020).

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