The Features of PSR J0220+3622 Radio Emission

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Abstract. The data of observations of the new pulsar J0220+3622 discovered at the PRAO FIAN at the frequency of 111 MHz, are presented. It is shown that the pulsar has such features as the subpulse drift and the flare activity. The estimations of the periods of the second and third classes are obtained.

Keywords: pulsars: general, techniques: radar astronomy

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1 Introduction

The Pushchino program of the pulsar search (Tyul'bashev et al. (2016)) is very effective for detecting peculiar objects, especially pulsars with variable radiation, because it is based on the long-term monitoring (daily for 5 years). Now more than 60 new pulsars and RRATs (Rotating Radio Transients) have been discovered (Tyul'bashev & Tyul'bashev 2015a,b, 2017; Tyul'bashev et al. 2016, 2017, 2018, 2020).

One of the features is a subpulse drift, that is a sequence of individual pulses or subpulses with a phase shift from one edge of the mean pulse profile to the opposite, forming drift bands on the longitude-time diagram (Drake & Craft 1968). Probably, this effect relates with the motion of a radiation field in the magnetosphere and associates with the pulsar emission mechanism. It is not a complete physical understanding of this phenomenon, but the most famous explanation is the model of Ruderman & Sutherland (1975), subsequently developed by many authors (for example, Filippenko & Radhakrishnan 1982; Deshpande & Rankin 1999; Gil et al. 2003). It explains the phenomenon of drift by the rotation of sub-beams around the magnetic axis ("carousel" model), including pulsars with complex, multicomponent pulse profiles (Rankin 1986). Another seldom feature is the flare activity, means that radio pulsars demonstrate a sporadic signal amplification of the pulse (for example, giant pulses (Sutton et al. 1971) or radio transients (McLaughlin et al. 2006) or different subpulses (Malofeev et al. 2016)).

2 Observations and Results

The observations were carried out at the Pushchino Radio Astronomy Observatory on the Large Phased Array (LPA) of the P. N. Lebedev Physical Institute at frequency of 111 MHz as a daily round-the-clock monitoring of the large area of the sky ($-9° < \delta < 42°$) using 96 beams. During the search, the data is recorded on the LPA-3 simultaneously in two modes: 6 channels with bandwidth of 400 kHz each, with the sample of 100 ms; or 32 channels (75 kHz each), with a sample of 12.5 ms. For detailed studying of known pulsars, the observations are carried out on the LPA-1M antenna using the standard digital receiver with a high frequency-time resolution: 470 channels x 4.88 kHz, time resolution is 2.46 or 5.12 ms.

The pulsar J0220+36 was one of the first discovered in PRAO in 2015 (Tyul'bashev & Tyul'bashev 2015a), the pulsar period is $P = 1.0297\,s$. It has a very wide average pulse profile of $\sim$ 220 ms and narrow single pulses (Fig. 1a, 2a,c). Because the integral pulse is rather weak (with a typical signal-to-noise ratio about 3.6), we need long-term observations for the dispersion measure (DM) definition, and obtained DM is equal to $46 \pm 1\,pc/cm^3$.

Fig. 1a shows a typical integrated profile after accumulation of 230 pulses, dynamic spectrum (Fig. 1b) and a sequence of 230 individual pulses (Fig. 1c). It is noteworthy that for this pulsar we found a complex multicomponent structure of individual pulses (Fig.2c), negative drift of subpulses (Fig. 1b), as well as short bursts of radiation, while the drift becomes especially clear. Thus, on one of 222 observation days (November 3, 2017), the pulsar showed the increased radiation activity (Fig. 2b). In three consequent pulses with a signal-to-noise ratio of 8 to 16, a three-component pulse structure with a clear drift is visible (Fig.2b). It should be noted that average pulse profile obtained from the search data (the time sample is $12.5\,ms$) by adding strong pulses, the complex structure of the pulse profile is also visible. (Fig. 3).

The analysis of time intervals between subpulses of individual pulses made it possible to measure the periods of the second and the third classes: $P_2 = 70 \pm 10\,ms$, $P_3 = 7 \pm 1$, as well as the drift rate $D = -20 \pm 5\,ms$ per period.

3 Conclusion

Observations of the new pulsar J0220+3622 were carried out with a high frequency-time resolution at the frequency of 111 MHz. The presence of a complex structure of individual pulses and two features in the radiation of this source were revealed: the drift of subpulses and the flare activity. The estimates of the periods of the second and the third classes were obtained: $P_2 = 70 \pm 10\,ms$, $P_3 = 7 \pm 1$.

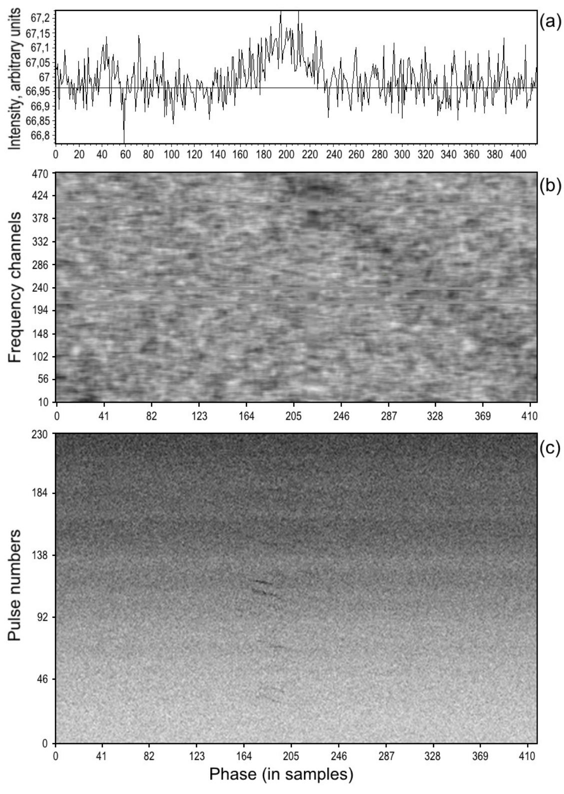

Fig. 1. The example of observations for pulsar J0220+36 02.01.2018. From top to bottom: a) integrated profile, b) dynamic spectrum and c) variations of pulse intensity during one observation session (230 pulses). The abscissa axis for all graphs shows one period in the samples (one sample is equal to $2.46\,ms$).

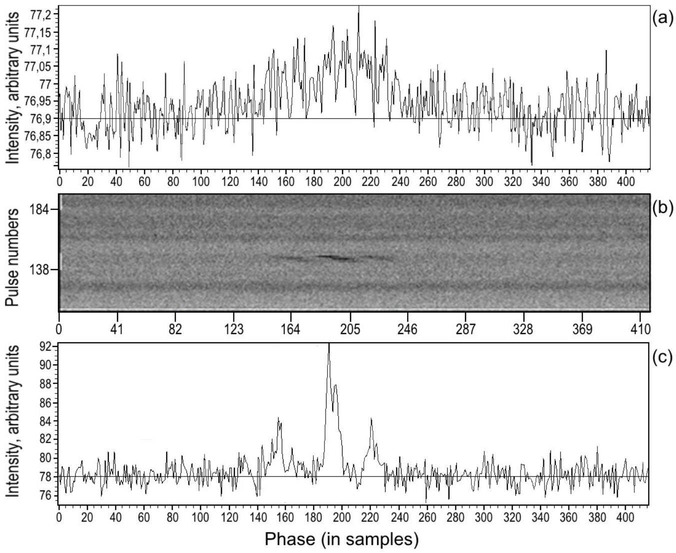

Fig. 2. a) – integrated profile of the observed pulsar; b) – intensity to pulse phase (samples the observational window) dependence for the 100 periods. Drift of the strong pulses is visible, c) – pulse profile of one of three strong individual pulses.

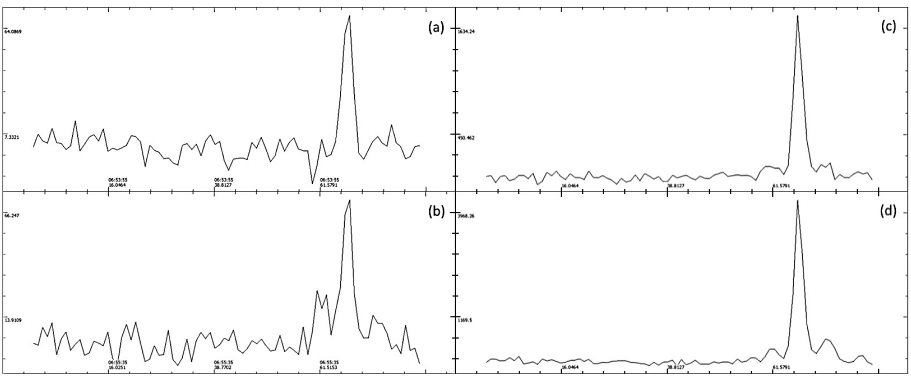

Fig. 3. Changes of the integral profile depending on the number of summed pulses: (a, b) - single pulses; (c) - the sum of 34 pulses; (d) - the sum of 109 pulses. The complex structure of the pulse is visible (sample is equal to 12.5 ms).

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