Search for Periodic Radio Emission in a Few Gamma-Ray Pulsars at 111 MHz

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Abstract. A search was conducted for periodic radio emissions from gamma-ray pulsars J0357+3205, J0554+3107, J1958+2846, J2021+4026, J2055+2539 in the summed power spectra. Harmonics corresponding to pulsar periods were not detected at the signal-to-noise level greater than 4. Upper estimates of the flux density of the studied pulsars were obtained.

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1 Introduction

Pulsars were discovered in the radio band in 1967 (Hewish et al. 1968), and a paper about the probable detection of pulsating gamma radiation from a pulsar in the Crab nebula (Vasseur et al. 1970) was published as soon as 1970. Prior to 2009, gamma and x-ray emission was detected in pulsars originally found in other wavelength ranges. The Fermi orbiting telescope, which was also designed to search for pulsars in the gamma range, showed that many of the sampled gamma objects observed in radiation in the continuum are gamma pulsars (Abdo et al. 2009) that do not have radio emission. Pulsars for which radio emission is not detected are called radio-quiet pulsars. Currently, for some pulsars, previously considered radio-quiet pulsars, detected periodic emission has been detected in the radio range at wavelengths from 2 GHz to 34 MHz (e.g. Malofeev et al. 2005; Camilo et al. 2009; Maan & Aswathappa 2014; Pei Wang et al. 2018; Tyul'bashev & Kitaeva 2019).

In this paper, an attempt is made to detect or confirm the periodic radio emission of several gamma-ray pulsars in observations made by the BSA LPI (Big Scanning Antenna of Lebedev Phisical Institute) radio telescope.

2 Observations, Processing, and Results

Details about the reconstruction of the BSA LPI Meridian radio telescope and its scientific programs are described in the works by Shishov et al. (2016); Tyul'bashev et al. (2016). The BSA LPI antenna has an effective area of 45,000 sq. m. in the direction of Zenith, its central frequency is 110.3 MHz, and the observation band is 2.5 MHz. The band is divided into 32 frequency channels with a width of 78 kHz, recording is performed with a readout time of 12.5 ms. Round-the-clock monitoring began in August 2014. The search for pulsars is conducted using power spectra. To increase sensitivity, power spectra related to one direction in the sky are summed (Tyul'bashev et al. 2020).

As an example, Fig.1 shows the possible harmonic with signal-to-noise ratio = 3.9 in the direction of the pulsar J2055+2539. The power spectra are summed over the 2014–2019 interval. Part of known interference was removed from the figure.

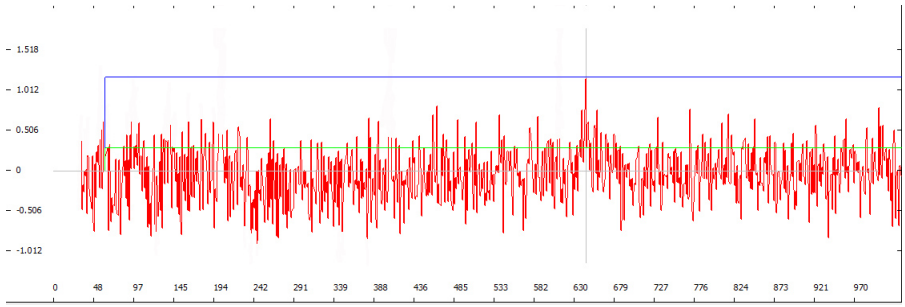

Fig. 1. Number of harmonics are shown on the horizontal axis, relative power on the vertical axis.

The absence of harmonics at the signal-to-noise ratio >4 in the summed spectra indicates absence of regular periodic emission in the meter wavelength range. In the accumulated power spectra, the sensitivity, searching for periodic emission, increases by about 40 times compared to the sensitivity in single power spectra. Considering the effective area of the radio telescope BSA LPI in the

direction of the Zenith, well-known periods of studied pulsars, as well as that the radio telescope is the antenna array, upper limits of flux densities were made for investigated pulsars: S<3.2 mJy (J0357+3205); S<1.4 mJy (J1958+2846); S<1.4 mJy (J2021+4026); S<1.3 mJy (J2055+2539); S<1.3 mJy (J0554+2107).

3 Discussion of Results and Conclusion

In the power spectra summed over a 5.5-year interval, no harmonics corresponding to the periods of gamma pulsars J0357+3205, J0554+3107, J1958+2846, J2021+4026, J2055+2539 were found. At the same time, for some of them emission in the radio range at the frequency of 111 MHz was previously detected, including by us for pulsars J0357+3205 (Tyul'bashev & Kitaeva 2019). Detection of pulsars using summed power spectra (Tyul'bashev et al. 2020) shows the correctness of the method used for signal accumulation. The absence in the summes power spectra of pulsars previously detected in the radio range most likely indicates their very sporadic radio emission, when short periods of activity alternate with very long periods of calm.

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