A NEW PULSAR PP 0943 AND THE PRINCIPAL CHARACTERISTICS OF ITS RADIO EMISSION

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Fig. 1

Figure 1: Fig. 1

Abstract

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A NEW PULSAR PP 0943 AND THE PRINCIPAL CHARACTERISTICS OF ITS RADIO EMISSION

(Presented by Academician V. A. Kotelnikov, 28 IV 1969)

1. At the Radio Astronomy Station of the P. N. Lebedev Physical Institute of the USSR Academy of Sciences in Pushchino (near Serpukhov), studies of pulsars are being carried out in the meter-wavelength range. The east-west arm of the DKR-1000 cross-shaped radio telescope is used; in this case the duration of a single observing session is 1 min. (^1).

In the course of our observations a new pulsar, PP 0943, was discovered; some data on it have already been reported (^2). It was first observed on 2 XII 1968 at frequencies of 89.6 and 90.4 MHz. Subsequent observations were also made at frequencies of 70 and 80 MHz over a period of more than a month. During 30 days of observations, emission from the new pulsar was recorded in 8 cases.

2. The intensity of the pulses of pulsar PP 0943 varies within considerable limits. Sharp changes from one pulse to the next are noticeable. Pulses are usually recorded in succession, 5-10 during a single observing session, and then disappear.

The maximum intensities in a pulse fluctuated within the range $(50 \div 250)\,10^{-26}\ \mathrm{W\,m^{-2}\,Hz^{-1}}$ with a receiver bandwidth of 80 kHz at a frequency of 70 MHz. Since the frequency band of the pulse emission is larger than 80 kHz, the intensity data given are equal to the spectral density of the emission of the pulsar pulses.

Fig. 1. Example of a copy of a recording of pulses of pulsar PP 0943 on 17 I 1968.
1 $-f = 70$ MHz, $\Delta f = 80$ kHz; 2 $-f = 70$ MHz, $\Delta f = 250$ kHz; 3 $-f = 80$ MHz, $\Delta f = 80$ kHz. For 1 and 2, distinct pulses are visible; for 3, pulses are not detected because of the fine structure of the spectrum.

Fig. 2. Intensity of pulses of pulsar PP 0943 for different days of observations; $f = 70$ MHz, $\Delta f = 250$ kHz. Segments with arrows give the values of the upper limit of the pulse amplitudes

Figure 2: Fig. 2. Intensity of pulses of pulsar PP 0943 for different days of observations; $f = 70$ MHz, $\Delta f = 250$ kHz. Segments with arrows give the values of the upper limit of the pulse amplitudes

It may be noted that even with a sufficiently wide band of 250 kHz there is rare registration of pulses compared with other pulsars (for example, CP 0950, CP 0808), which led to low accuracy in determining its parameters. Figure 1 shows copies of pulse recordings with narrow and wide receiving bands. Figure 2 gives the amplitudes of all pulses registered at a frequency of 70 MHz.

3. The right ascension is $\alpha_{1950} = 9^h 43^m 15^s \pm 30^s$. The declination is about 8°. Pulsar PP 0943 was found while the radio telescope was pointed at pulsar CP 0950, i.e., when the antenna was directed toward the region with declination +8°. It was not possible to refine the declination because of the small number of recordings. The probable error in declination is ±3°.
4. The period of the principal pulses is $P_1 = 1.093 \pm 0.003$ sec. It should be noted, however, that the time intervals between pulses vary by an appreciable amount. Apparently this is explained by the complex and, in particular, double structure of the pulse, which changes with time.

For a more detailed analysis, the dependence of the time of appearance of the pulse was constructed for the most reliable recording with a narrow band. The result is shown in Fig. 3.

As can be seen, for the first 5 pulses a gradual shift of their position is indicated. Then the pulses are absent, but for the series that appears again the time of their appearance is shifted; on average, a displacement of the pulse positions is observed, characterized by the inclined dashed curve. The magnitude of the time displacement between the first and second series of pulses is 55 ± 10 msec.

Fig. 2. Intensity of pulses of pulsar PP 0943 for different days of observations; $f = 70$ MHz, $\Delta f = 250$ kHz. Segments with arrows give the values of the upper limit of the pulse amplitudes.

Jumps of the same kind, with a value $P_2 = 53.6$ msec, are observed in pulsar CP 0808 ([3]); they are explained by the presence of a period of the second class. This gives grounds for the assumption that pulsar PP 0943 also has a period of the second class P_2. Both these values of P_2 differ appreciably from the values of P_2 for pulsars AP 2015 + 28 ($P_2 = 10.7$ msec) and CP 1919 ($P_2 = 15.5$ msec), obtained in ([4]).

Such a marked difference in the values of P_2 gives grounds to suppose that we are dealing with a wide range of physical characteristics of neutron stars, with

Fig. 3

Figure 3: Fig. 3

which pulsars are usually identified at present.

5. The rate of frequency drift was determined from the time of appearance of pulses at different wavelengths and was found to be 3.7 ± 0.1 MHz$\cdot$sec^{-1} at a frequency of 81.5 MHz, which corresponds to a total number of electrons along the line of sight of 17.5 pc $\cdot$ cm^{-3}. It may be noted that this value differs appreciably from the value 2.98 pc$\cdot$cm^{-3} for pulsar CP 0950, which has coordinates close to those of pulsar PP 0943.

6. Let t_i be the intrinsic duration of a pulsar pulse, df/dt the frequency drift, and ΔF the receiver band. Then the observed total dura-

the pulse duration t_{n} for a Gaussian pulse shape and a Gaussian frequency characteristic of the receiver

$$t_{\mathrm{n}} = \sqrt{t_{\mathrm{i}}^2 + \left[\Delta f \, (df/dt)^{-1}\right]^2}\,. \tag{1}$$

It is seen from Fig. 1 that the pulse duration is indeed noticeably larger in the case of a wide band.

Expression (1) makes it possible, knowing df/dt and t_{n}, to find the true duration of the pulsar t_{i}.

The duration of the radiation pulse at a frequency of 70 MHz (determined from a record in an 80-kHz band) is $t_{\mathrm{i}} \sim 60$ msec.

Fig. 3. Positions of the pulses in time relative to moments determined by an integral number of periods P_1. 11 I 1969, $f = 80$ MHz, $\Delta f = 80$ kHz. Maximum errors are shown. The dashed straight lines characterize the mean displacement of the positions of the pulses; their shift gives the value P_2.

7. From a comparison of records at two nearby frequencies, and also with narrow and wide bands, a fine frequency structure of the spectrum of this pulse is revealed, with a characteristic scale of hundreds of kilohertz.

From analysis of the records it follows that the ratio of intensities at two nearby frequencies (with a frequency separation of 0.8 MHz) can change by several times from one pulse to the next; these changes are also observed after several pulses have elapsed.

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1. Yu. I. Alekseev, V. V. Vitkevich, Yu. P. Shitov, DAN, 187, No. 2 (1969).

2. Yu. I. Alekseev, V. V. Vitkevich, Yu. P. Shitov, Preprint, P. N. Lebedev Physical Institute, Academy of Sciences of the USSR, No. 196, Moscow, 1968.

3. Yu. I. Alekseev, V. V. Vitkevich, Yu. P. Shitov, Astr. Circular, No. 495 (1969).

4. F. D. Drake, H. D. Craft, Nature, 220, Oct. 19, 231 (1968).

Note: Figure translations are in progress. See original paper for figures.