# RADIO EMISSION OF THE PULSAR CP-1919 IN THE METER-WAVE RANGE

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## Abstract

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# RADIO EMISSION OF THE PULSAR CP-1919 IN THE METER-WAVE RANGE

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During the period April–July 1968, regular observations of the radio emission of the pulsar CP-1919 in the meter-wave range were carried out on the DKR-1000 range cross-shaped radio telescope in Pushchino. The present article gives the main results of this work.*

1. The observations were carried out using the East–West arm of the DKR-1000. Since the sensitivity of the radio telescope is sufficiently high, and the radio emission of the pulsar at times, as is known, practically disappears, in order to increase the duration of the source’ s passage through the antenna pattern it was decided to conduct the investigations on one third of the entire antenna. This corresponded to a beam width of about 30′ at a wavelength of 3.5 m; the source passage time was about 2 min.

Regular observations were carried out at a frequency of 93 MHz, and individual sessions at frequencies of 110, 106, 92, 73, and 61 MHz. The passbands of the receivers varied from 1 MHz to 80 kHz. The recording system used the compensation method. EPP-09 recorders were used as chart recorders, as well as oscillographs recording on photographic paper. The time constant, which was chosen in accordance with the indicated passbands and reception frequencies, varied from 0.15 to 0.05 sec. The intensity was calibrated using the source 3C-409. Figure 1 gives copies of recordings of the pulsar CP-1919 at different frequencies. As can be seen, each individual pulse was recorded very distinctly. However, on a number of days the signals were not recorded because of their small magnitude.

2. Using the broad range of frequencies, we analyzed the delay times of the pulses at different wavelengths:

| $f_1 - f_2$ | $110 - 106$ | $110 - 93$ | $110 - 72.7$ | $110 - 61.1$ |
|---|---|---|---|---|
| $T_2 - T_1$ | 0.35 | 1.77 | 5.56 | 9.74 |

In the first row are given the frequencies for which the delay time was measured; in the next row, the delay time in seconds. Analysis of these data shows that down to the frequency 61 MHz there is observed a quadratic dependence of the change in delay time on wavelength. This quite obviously proves that the cause of the delay of the pulses at the longer wavelength is the difference in their group velocities in the interstellar plasma. However, this result does not exclude the possibility that part of the delay time is due to processes in the source itself. The total number of electrons in a column with area 1 $\mathrm{cm}^2$ that produces the delay given above is $3.8 \cdot 10^{19}$, which is in good agreement with ([1-3]). If, on the basis of the data given, one plots the dependence of $T_2 - T_1$ on frequency, it turns out to be a straight line passing through the origin. Thus, the generation of pulses occurs simultaneously at all wavelengths, or there is a delay in the source itself according to the same law as follows from the dispersion. In the latter case, the total number of electrons between the source and the observer will correspondingly be smaller, so that the indicated figure is an upper limit. At a density of 0.01 el/$\mathrm{cm}^3$ it corresponds to a distance equal to 4000 light-years.

3. In Fig. 2a the mean values of the intensity of the observed pulses are given for different days of observation. The arrows indicate the days for which only an upper limit to the intensity can be estimated. It is interesting to note that, on average, a decrease in the intensity of the radiation of this source was observed during the period from April to July 1968. It is interesting to compare our data with those of work ([3]), which is done in Fig. 2b. There are shown (by crosses) the data from work ([3])—the maximum values of the pulse intensity in the 1 MHz band—and analogous data from our observations. In doing so, the data of ([3]) were recalculated for our frequency; the correction was made for a spectral index of 1.5. As can be seen, higher intensities follow from our observations. It may be concluded that the radiation intensity of the pulsar CP-1919 in the period from August-September 1967 to April-May 1968 increased by a factor of 3-5, and then in July decreased to its former value. Thus, apparently, the longest of the known characteristic times of variation of the emitted intensity is revealed, with a value of the order of 1 year.
4. In our observations we found variations of intensity with a characteristic time of several minutes, as was indicated in work ([3]). In addition, attention is drawn to the presence of quite distinct variations of the pulse intensity with a characteristic time of the order of 3-10 sec. This is seen from Fig. 2c, which gives the amplitudes of successive pulses of radiation. It is interesting to note that several pulses form, as it were, a group with a characteristic rise time of the order of 1 sec and a slower decrease of

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* These results were reported on 15 May 1968 at the council on the problem "Radio Astronomy," on 29 May 1968 at a meeting of the OOFIA, and on 5 September 1968 at the All-Union Conference on Radio Astronomy in Riga (see ([5])).

intensity. In Fig. 2c such groups can be seen, for example, in pulses 5-12 and especially clearly in 13-16. It is curious to note that similar characteristic groups of pulses are seen in the work of the Australian authors ($^4$) for pulsar CP-1133. If this regularity proves to be characteristic and recurrent for a number of pulsars, then this fact will undoubtedly help to reveal the nature of their radio emission. At the same time, of course, in further analysis one should try to trace an analogous dependence not for the whole pulse, but for its separate components.

5. We specially considered the question of whether the short-period variations indicated in item 4 are the result of scintillation of the source on inhomogeneities of the interplanetary plasma. For this purpose observations were carried out at night, when the indicated intensity variations are in any case less than 5-10%. As can be seen from Fig. 4, these variations cannot be explained by scintillations on inhomogeneities of the interplanetary plasma, since the actual changes in intensity are significantly larger. In this connection, the statement made in work ($^3$), according to which the short-period variations are due to the interplanetary plasma, seems to us unfounded.

6. The correlation of pulse amplitudes at nearby frequencies was investigated, in particular at frequencies 92-93 MHz. Figure 3 gives the amplitudes of one and the same pulse at these frequencies. As can be seen, one may note a good correlation, amounting, as calculations show (taking into account decorrelation of measurement errors), to a value equal to 0.77. Thus, no fine structure is detected in the spectrum of the radio emission. This also means that if the amplitude variations are caused by scintillations on inhomogeneities of the interstellar plasma or on plasma located near the source, then for the indicated frequency the screen must not be so thick

so as to noticeably disrupt the correlation of the amplitudes of pulses at frequencies differing from one another by 1 MHz.

7. We analyzed the spectra of individual pulses of CP-1919 in the meter-wave range. Figure 4 gives the spectra of individual pulses. As can be seen, despite the considerable scatter in the spectral indices, exceeding the measurement errors, on average the intensity dependence is quite similar for different pulses. The mean spectral index is $\alpha_{\text{av}} = 1.52 \pm 0.13$, with an rms scatter $\sigma_\alpha = 0.5$ (including measurement errors). Since pulsar CP-1919 is not polarized and the spectrum measurements were carried out at night (which excludes scintillation in the interplanetary plasma), the observed scatter of pulse spectra does in fact occur in the radio-emission region of the pulsar itself. It is interesting to note that in work ($^2$) a spectral index $\alpha_{\text{av}} = 1.5$ was also obtained, but only for the mean values of the amplitudes of the strongest pulses, regardless of whether these pulses are common to the measured frequencies or not. If one assumes that these spectra are equivalent on average—which may well be the case provided that the mean spectra of the pulses are independent of their amplitude

and provided that the observational series in (2) is sufficiently long—then one may conclude that there are no noticeable variations of the spectrum of pulsar CP-1919 with a period of order 2-3 months. This is important for analyzing the nature of the observed pulse variations.

8. An analysis was made of the correlation of the intensity of the same pulses at the comparatively widely separated frequencies 110–61 MHz. Even in this case of widely separated frequencies, a reliable correlation was found; the correlation coefficient is $R = 0.3$. Thus, the spectral distribution of energy in the meter-wave range is described by a smooth curve with a noticeable correlation of amplitudes for these frequencies, which are quite far apart from one another.
9. At present two main models of a pulsed source of radio emission are being considered. According to the first model, which, in particular, Soviet theorists support and develop, a pulsar is a white dwarf with radial oscillations. The second point of view is that a pulsar is a rotating object, most likely a neutron star. This point of view is supported by a considerably smaller number of scientists. However, it seems to us that it is precisely this system that obtains. We believe that the result we obtained, described in item 4, concerning the rapid rise and slow decline of the amplitudes of the pulses, speaks in favor of this model.

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## REFERENCES

1. F. G. Smith, Nature, **218**, 325 (1968).
2. F. D. Drake, E. J. Gundermann et al., Science, **160**, 503 (1968).
3. A. Hewish, S. J. Bell et al., Nature, **217**, 709 (1968).
4. O. B. Slee, M. M. Komesaroff, P. M. McCulloch, Nature, **219**, 342 (1968).
5. Yu. I. Alekseev, V. V. Vitkevich et al., Preprint FIAN, No. 126.

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