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Abstract

Full Text

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DETECTION OF LINEAR POLARIZATION OF THE PULSAR MP 0628 AND SOME CHARACTERISTICS OF ITS RADIO EMISSION IN THE METER-WAVE RANGE*

(Presented by Academician V. A. Kotelnikov on 21 V 1970)

In paper ([1]), Australian scientists reported the discovery of the pulsar MP 0628 and some characteristics of its radio emission at a frequency of 408 MHz.

We investigated this pulsar in the meter-wave range on the East–West arm of the cross-shaped radio telescope (with reception of one linear polarization) in Pushchino. In doing so, the linear polarization of this pulsar was detected, the rotation measure of the plane of polarization MR was measured, and some parameters listed below were obtained.

For the investigations a recently created multichannel radio receiving installation was used. It has 12 receiving channels with a passband for each channel and with spacings between the frequencies of adjacent channels equal to 70 kHz. The mean receiving frequency can be varied over wide limits, which makes it possible to carry out studies of the fine spectral structure of pulsar pulses at different wavelengths.

In November–December 1969 we carried out a series of observations of the pulsar MP 0628 at frequencies of 105 and 86 MHz. It turned out that the dispersion measure of this pulsar is equal to 34.4 $\text{pc} \cdot \text{cm}^{-2}$, which is much larger in comparison with the value indicated in ([1]), equal to 5 $\text{pc} \cdot \text{cm}^{-3}$. Figure 1 shows a copy of the recording of three pulses of MP 0628 on the multichannel installation, where the relatively large delay time of the pulses at nearby frequencies is visible, indicating a large value of the dispersion measure.

Figure 2

Figure 2: Figure 2

Fig. 1. Copy of the recording of pulses of the pulsar MP 0628 on the multi-channel installation,
$f = 86$ MHz

It was found that the amplitudes of the pulses differed markedly in magnitude in the different receiving channels. This is seen from Fig. 2, where the relative values of the pulse energies at nearby frequencies are given. Analysis shows that we are dealing with an effect caused by rotation of the plane of polarization, and not with scintillation in an inhomogeneous interstellar plasma. The following may serve as proof of this conclusion.

* The work was reported at the All-Union Conference on the Physics of Pulsars in Moscow on 19 XII 1969.

First, the observed form of the curve of pulse intensity versus frequency (which is seen, in particular, in Fig. 2a) has a periodic character. With a fine structure of the spectrum caused by an inhomogeneous interstellar plasma, the spectral curve differs substantially in its form from a periodic one: the frequency intervals occupied by intense radiation are considerably narrower than the intervals in which radiation is absent. The latter is clearly seen, for example, from the curves obtained in paper

Fig. 2. Experimentally obtained dependences of the intensity of pulses of pulsar MP 0628 on frequency. Each curve corresponds to one pulse. The width of the band of one channel and the spacing between channels are equal to 70 kHz.
a –observations of 29 XI 1969, $f_{\text{cp}} = 86$ MHz; *b* –observations of 30 XI 1969, $f_{\text{cp}} = 105$ MHz

([2]), and also from a number of our observations of the fine structure of the spectra of pulsars CP 0808, CP 0950, and others.

Second, taking into account the magnitude of the dispersion measure of pulsar MP 0628, one can estimate for it the characteristic bandwidth of the fine structure of the spectrum caused by scintillations in the interstellar plasma.

If, as the characteristic bandwidth, one takes such a value B_η that smooths the fine structure to the level 0.5, then the value B_η turns out to be many times smaller than that actually observed. Indeed, according to the data of paper ([2]), at a frequency of 408 MHz a pulsar with $DM = 34$ pc $\cdot$ cm^{-3} should have $B_\eta \cong 700$ kHz; if we now take the weakest dependence of B_η on frequency, with a power-law exponent equal to 2, then for $f = 105$ MHz we find $B_\eta = 40$ kHz, which is approximately an order of magnitude smaller than follows from the measurements (see Fig. 2).

Thus, the spectral curve obtained cannot be explained by scintillations in an inhomogeneous interstellar plasma.

Finally, it is well known that, under Faraday rotation, the frequency bandwidth Δf between minima (or maxima) of intensity depends on frequency according to a cubic law. A check shows that in our case this relation is satisfied. Indeed, the measurement results give: for $f = 86$ MHz, $\Delta f = (250 \pm 30)$ kHz; for $f = 105$ MHz, $\Delta f = (490 \pm 50)$ kHz, which fit the dependence noted above. All these arguments taken together lead to the conclusion that the observed effect is caused by rotation of the plane of polarization in the interstellar-

medium, and not by scintillations on its inhomogeneities. The principal parameters can now be found.

The degree of linear polarization of the radio emission proves to be very high, and its limit is determined by the sensitivity of the apparatus.

For frequencies of 105 and 86 MHz we find that $P = (I_{\max} - I_{\min})/(I_{\max} + I_{\min}) \geqslant 80\%$. It should be noted that during one observing session, lasting about 1 min, the angle of linear polarization of the pulses does not change, but remains constant to within $\pm 30^\circ$.

Next, the angle of rotation of the plane of polarization is readily determined. At a frequency of 86 MHz it is found to be 550 rad, i.e. $MR = 45$ rad/m^2. These data make it possible to find, along the line of sight, the mean value H of the longitudinal magnetic field of the interstellar medium:

$$H = 1.6 \cdot 10^{-6} \text{ Oe.}$$

It is appropriate to note here that analogous observations with the same apparatus were carried out by us for the pulsar CP 0328, whose polarization and rotation measure had already been reported in the literature [3]. For this pulsar the pattern of the change of pulse intensity with frequency is similar to the pattern observed for the pulsar MP 0628, and it also shows a high degree of polarization in the range (86–105) MHz, $P \geqslant 80\%$. For CP 0328, according to our data, $MR = 50$ rad/m^2, and the magnetic field $H = 2.4 \cdot 10^{-6}$ Oe, which is somewhat smaller than was reported in [3]. For the pulsar MP 0628 we also measured the pulse duration in the range (86–105) MHz, the flux density of the strongest pulses, and refined the period P_1. The principal results obtained from observations of the pulsar MP 0628 are as follows:

Period $P_1 = 1.2446 \pm 0.0005$ s.

Dispersion measure $DM = \int N_e dx = 34.36 \pm 0.08$ pc $\cdot$ cm^{-3}.

Mean pulse duration at a frequency of 86 MHz (at the 0.5 level), 28 ms.

Flux density in the pulse (of the strongest pulses) at a frequency of 100 MHz, $180 \cdot 10^{-26}$ W $\cdot$ m^{-2} $\cdot$ Hz^{-1}.

Degree of linear polarization at frequencies 105–86 MHz, $P \geqslant 80\%$.

Rotation measure $MR = 45$ rad/m^2.

Longitudinal magnetic field along the line of sight $H = 1.6 \cdot 10^{-6}$ Oe.

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CITED LITERATURE

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