ON VARIABILITY OF OBSERVED POLARIZATION PARAMETERS OF GALACTIC RADIO EMISSION AT METER WAVES

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ABSTRACT. The polarization temperature T_p variations, which exceeded errors of measurements were observed already during the initial (1958-1962) and then the following measurements of linear polarization of galactic radio emission at meter waves. The long term regular polarizations observations carring out at NIRFI Radio Astronomical Observatory "Staraya Pustyn'" in the range 150-290 MHz, prove the existences of variability of available polarization temperature T_p and also position angle χ_0, in the broad time intervals. Data analyses shows that variations of T_p and χ_0 are not connected directly with solar activity because there are no correlations with indices R9 and C9. Cross-correlation analyses of T_p variations and galactic cosmic rays intensity I_c testify to there statistical dependence. Since 1981 till 1984 at 290 MHz nine time intervals has been found, each of them lasting about one month, within the limits of which correlation coefficients $R(T_p, I_c)$ are in interval $0.5 \pm 0.2 < |R| < 0.8 \pm 0.1$. Among possible reasons of polarization parameter variability there are effects of propagation of radio waves in inhomogeneous magnetoactive plasma of geleosphere, emission of non-stationary fluxes of high energy electrons in the interplanetary medium, and also linearly polarized component of radioemission, caused by Thompson scattering of solar radio emission.

Key words: Galactic radio emission, linear polarization, variability, metre band, cosmic rays.

1. Introduction

Already during initial (1958-1962) measurements of linear polarization of galactic radio emission at metre waves the polarization temperature (T_p) variations, which exceeded errors of measurements were observed. There were irregular and very large (up to 100%) daily variations of T_p and also slowly changes of T_p according the time scale about several months and years depending on phases of solar activity (Razin 1958, 1964). T_p variations also observed during further polarization measurements carried out at the NIRFI Radioastronomical Observatory "Staraya Pustyn'" at 210 MHz (Kapustin et al. 1973), in the frequency interval 195-215 MHz (Teplykh et al. 1980) and at 150 MHz (Teplykh et al. 1985).

2. Results of measurements and dicussion.

In the course of long-term regular observations of the Galactic radio emission linear polarization at 290 MHz at "Staraya Pustyn'" it has been obtained a large amount of data testifying to noticeable variations of the brightness polarization temperature T_p and polarization plane position angle χ_0.

The data on T_p and χ_0 variations of linearly polarized radio emission for the region of strong polarization with Galactic coordinates $l = 147°$, $b = +8°$ (PGA147 + 8) and for North Celestial Pole region (NSP) at 290 MHz are given in (Teplykh et al. 1990) for the period 1977-1988. There have been significant T_p variations for these regions in a wide spectrum of time intervals: short-term (with a period of several days), sometimes very strong (nearly two times) as well as yearly recurrent seasonal T_p variations. Special attention must be given to synchronous T_p variations of both $GPA147 + 8$ and NCP regions observed simultaneously in 1980-1981 with a period of about a year (Kovalchuk O.M., Teplykh A.I. 1991).

The values of χ_0 have also temporal variations. For NCP they are from $-30°$ up to $-10°$ in the equatorial coordinate system with the mean value $< \chi_0 >= -22° \pm 2°$. However, from april to July 1984 and in May-June 1985 we observed values $+20°$ and $+10°$, respectively, where in the second case it was registered a smooth change of χ_0 by 30° for a period of one month. It should be noted that during these two very intervals we have registered the strongest short-term fluctuations accompanying the growth of T_p.

To clear up the reasons of polarization characteristic variability we have compared T_p with the geomagnetic activity index $C9$ and solar activity index $R9$ fore the period 1980-1984. The analysis of the data has shown that there is not any definite dependence of T_p on $C9$ and $R9$ although monthly average values of T_p increased gradually with the growth of the solar activity starting with the minimum of solar activity in 1983-1984 up to 1988 approximately by $(15 \div 20)\%$ per year.

Seaking the reasons of polarization parameters variability we tried to find out the correlation between T_p and daily average values of cosmic ray intensity I_c. For this purpose we used the measurement results of T_p obtained at "Staraya Pustyn'" ($\lambda = 43^\circ.63$, $\varphi = 55^\circ.66$) at 290 MHz in period of 1980-1984 and neutron monitoring data obtained at stations Huankayo ($\lambda = 248^\circ.67$, $\varphi = -12^\circ.03$) and Tokio ($\lambda = 139^\circ.72$, $\varphi = 35^\circ.75$) and published in the monthly journal "Solar-Geophysical Data". These stations were chosen for the analysis as those having the highest energy detection threshold ($13.01GV$ for Huankayo and $11.50GV$ for Tokyo) which registered the events associated mainly with high-energy cosmic rays of Galactic origins (so the events associated with solar cosmic rays were practically excluded). The cosmic ray intensity for these data is characterized by a number of events in hour (cts/h) divided by scale factor 100 for Huankayo and 256 for Tokyo. The correlation coefficient $R(T_p, I_c)$ and its error σR were calculated by the standard formulas. Correlation coefficient R can be both positive when T_p increases with growth of I_c and negative when T_p decreases with the growth of I_c.

At the early stage of analysis we have plotted the dependencies $T_p(I_c)$ for $PGA147+8$ (42 points) and NCP (20 points) for the period October 1980 - December 1981 using Huankayo station data. The correlation coefficients turned to be $+0.44 \pm 0.12$ and $+0.36 \pm 0.19$, respectively.

We did not carry out regular observations of $PGA147+8$ since the end of 1981, so the further results are related only to NCP region observations. We have plotted $T_p(I_c)$ for the period September 1980 - December 1984 for Huankayo station data (152 points) and for Tokyo station data (213 points). The correlation coefficients are -0.51 ± 0.06 and -0.47 ± 0.05 respectively.

The fact that at the positive correlation coefficient related to only a part of the time interval taken the correlation coefficient related to the whole period of observation is negative suggests that at the shorter time intervals one can expect lager values of the correlation coefficients both positive and negative ones. To prove this suggestion we calculated then the "sliding" correlation coefficient R on time intervals of about $20 \div 30$ days: each recurrent value of R refers to the following interval the beginning and end of which are shifted by one or several days ahead. We have got in this way the sign-alternating dependence of R on time. The Table 1 gives the values of R corresponding to maxima of this dependence and exceeding module 0.5.

Table 1.

R	ΔR	Period	Year
-0.50	0.24	02-28.09	1980
-0.73	0.16	28.04-25.05	1981
+0.51	0.23	29.09-06.10	1983
+0.54	0.24	05-19.12	1983
+0.53	0.18	09.02-03.03	1984
+0.72	0.14	19.05-26.06	1984
+0.58	0.20	28.06-26.07	1984
-0.61	0.16	21.08-14.09	1984
-0.81	0.11	26.09-25.10	1984

Then we have compared the values T_p and I_c averaged over the time intervals given in Table 1. The correlation coefficient calculated on the basis of these values is equal to $R = -0.69 \pm 0.17$.

Thus, the observational data make it possible at this step of work to make a conclusion on a relation between the temperature of linearly polarized component of the cosmic radio emission T_p in the metre radio wave band and the cosmic ray intensity I_c. This relation is rather complicated. There are intervals with significant correlation coefficients of T_p and I_c values being both positive or negative one. Between these intervals there are periods where the correlation coefficient is small and as a rule changes its sign. Some periodicity of about $1.5 \div 2$ months can be seen in the change of the correlation coefficient sign.

The next stage of the work should involve a further treatment of experimental data on T_p after 1984 up to 1998 using the data on cosmic ray intensity I_c obtained during ground-based experiments as well as on board the spaceships and earth satellites.

3. Conclusion

It is apparent the variability of cosmic radiation polarization parameters in the metre wave band is associated with the processes occurring in the near space: possibly in the interplanetary medium or in a local interstellar medium and the region of its interaction with the Solar system. This is testified first by short-term fluctuations of T_p and as well as by their seasonal behaviour. Besides, the linearly polarized radio emission from far Galactic regions is depolarized in the metre band due to the difference of polarization plane Faraday rotation along the line of sight. Nondepolarized radiation remains only what is generated nearly the Solar system and the linear size of the generation area along the line of sight is contracted with the wavelength making it possible "to sound" the interstellar medium along the line of sight (Razin V.A., Hizhnyakova I.P. 1969). This effect is to be particularly pronounced in the regions where the Galactic magnetic field is parallel to the line of sight.

In this connection NIRFI has planned at a number of frequencies in the metre band and has started this year at 290 MHz the observations of the regions with coordinates $\alpha = 22^h, \delta = 55°$ and $\alpha = 19^h$, $\delta = 14°$, as well as the apex region $\alpha = 18^h$, $\delta = 30°$.

To create a physical model explaining the reasons of polarization parameter variability it is also necessary to consider the effects of radiowaves propagation in inhomogeneous magnetoactive plasma of heliosphere, the radiation of high-energy nonstationary electron currents in the interplanetary medium, as well as the possibility of radio emission linearly polarized component generation in an inhomogeneous interplanetary medium due to the Thompson effect.

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