

THE EFFECT OF IONOSPHERE INHOMOGENEITY ON MAGNETIC PULSATION POLARIZATION. 2. MAGNETIC DISTURBANCE ON THE GROUND AS A FUNCTION OF INHOMOGENEITY MAGNITUDE

E.Belova, E.Pchelkina, W.Lyatsky, and A.Pashin (*Polar Geophysical Institute, Apatity, Russia*)

1.Introduction

In the paper by Maul *et al.* [1990] the polarization ellipses on the ground observed during the heating experiment in October-November, 1984 near Tromsø, Norway, were presented, and their characteristics were compared with those calculated using the model simulation. In some cases the discrepancy between these results was rather large. In that paper it was mentioned that during one of the experiments near the ionospheric heated region the quiet auroral arc was observed. Therefore the ionosphere was essentially inhomogeneous that might influence the polarization characteristics of the magnetic pulsations.

The effect of ionospheric inhomogeneity on the magnetic pulsation polarization for circular-polarized source in the ionosphere has been investigated by Belova *et al.*, part 1 (this issue). This paper can be considered as continuation of the research. Here the dependence of distribution and characteristics of polarization ellipses on value of conductivity of the inhomogeneity is investigated. Finally in Section 4 we simulate polarization characteristics of artificial magnetic pulsations generated due ionosphere heating with taking into account presence of an ionospheric inhomogeneity.

2.Magnetic effect on the ground due to ionospheric inhomogeneity

According to the paper by Belova *et al.*, part 1 we take into consideration two kinds of ionospheric inhomogeneities: a large-scale strip and a meso-scale strip. The dipole source is that of the part 1. The geometry of considered ionosphere region and inhomogeneity are presented in Fig.1 and 3 of the paper by Belova *et al.*, part 1. For calculation of magnetic disturbance on the ground generated by dipole source in the inhomogeneous ionosphere we at first determine the electric potential in the ionosphere and the current function of equivalent ionospheric current disturbance using formulas from the part 1 (this issue). For further analysis we use the differences between these calculated electric potentials and current functions and those calculated for the same source in the homogeneous ionosphere. These differences characterize the contribution due to ionospheric inhomogeneity. From the distribution of the equivalent currents in the ionosphere we obtain magnetic disturbance on the ground using the Biot-Savart law.

Dependence of the magnitude of maximum magnetic effect on the ground due to inhomogeneity on its conductivity value is the following. Up to some value of conductivity the maximum magnetic effect for wide strip seems to be predominant over magnetic disturbance for the narrow strip and then effect gets inversed. We can explain this effect as follows. For any values of inhomogeneity conductivity the wide strip of enhanced conductivity "attaches" to itself larger current disturbance than the narrow strip. And for small values of strip conductivity the wide strip gives greater magnetic effect on the ground than the narrow strip does. However for large inhomogeneity conductivity for the narrow strip the maximum currents are concentrated in it, and a current stream is formed. When the strip width extends the current density decreases and magnetic disturbance on the ground containing integrated effect, decreases too.

3. Polarization of magnetic disturbance on the ground

For investigation of the polarization characteristics of magnetic disturbance on the ground due to two kinds of ionosphere inhomogeneity in dependence on the magnitude of inhomogeneity conductivity, we shall plot the hodograms for magnetic disturbance on the ground normalized on maximum amplitude of this disturbance corresponding to each conductivity value.

It seems that for the wide strip the spatial distribution of polarization ellipses doesn't depend on value of strip conductivity. Therefore this distribution of the polarization ellipses calculated for one value of strip conductivity of 30 S presented in Fig.2 of part 1 is valid for any values of strip conductivity. In spite of asymmetry of momentary polarization vectors relatively to the vertical line crossing the point being the projection of the source point on the ground, we have this symmetry for polarization ellipses as a result of the magnetic disturbance evolution during a pulsation cycle.

For the narrow strip-like inhomogeneity the situation becomes more complicated.

Fig.1 presents the hodograms of magnetic disturbance vector on the ground due to the narrow strip-like inhomogeneity for two values of strip conductivity: 7 S and 200 S. The background conductivity values $\Sigma_{H0}=\Sigma_{P0}$ are equal to 5 S. From Fig. 1 it is seen that the symmetry of these distributions which is characteristic for those for the wide strip disappears. One can see that distribution of polarization ellipses becomes dependent on the strip conductivity value. With increase of strip conductivity the position of the line separating the regions with different polarization rotation senses changes, and this line becomes more curved.

The main axis of the ellipses is turned and becomes oriented along the separating line, what is associated with current disturbance stream formed for great values of strip conductivity. Polarization at some points on the ground changes from nearly circular to nearly linear. That is the ellipticity at the point decreases.

4. Polarization of magnetic pulsations generated due to ionospheric heating

Let's take into consideration the October 26, 1984 heating experiment which results were presented by *Maul et al.* [1990] in Fig.17. We are interested in 1 second modulation because in this case the source being the heated region of enhanced conductivity has elliptic polarization [Belova and Lyatsky, 1993]. For calculations of conductivity disturbance we use the data on initial undisturbed electron density profile, ionospheric electric field, parameters of the heating wave and the numerical model of artificial magnetic pulsation generation presented by *Pashin et al.* [1995].

Fig.2 presents the disturbed height-integrated Hall and Pedersen conductivities during one cycle of square-wave modulated heating. The heating power is switched on and off at the moments 1 and 3 correspondingly. During first milliseconds from 1 to 2 moment the conductivities change due to the variation of electron collision frequency. The electron density change gives contribution in the conductivity disturbances from 2 to 3 moment. The polarization of ionospheric conductivity disturbance becomes quasi-elliptical, and with the background uniform electric field directed to the north the polarization of a dipole source due to ionospheric heating is quasi-elliptical as well.

Then we calculate the distribution of polarization ellipses of magnetic disturbance on the ground for this source being the circle with radius of 10 km. In Fig.3 the distribution of hodographs of magnetic variations of fundamental modulation frequency on the ground is shown for the case of the homogeneous ionosphere. The polarization of magnetic disturbance at the source point projection on the ground is elliptical, though the ellipticity value is near 1. The central symmetry which is inherent to circular source polarization [Belova et al., part 1] disappears in this case.

During the October 26, 1984 experiment the heated region was near the northern border of a quiet auroral arc (*Maul et al.*, 1990). So far as we had no additional data, we carried out the calculations for the strip with the conductivities $\Sigma_{H2}=126$ S, $\Sigma_{P2}=23$ S enhanced by two orders of value in comparison with undisturbed ones, the width of 30 km and that is at the distance of 50 km southward of the source (heated region).

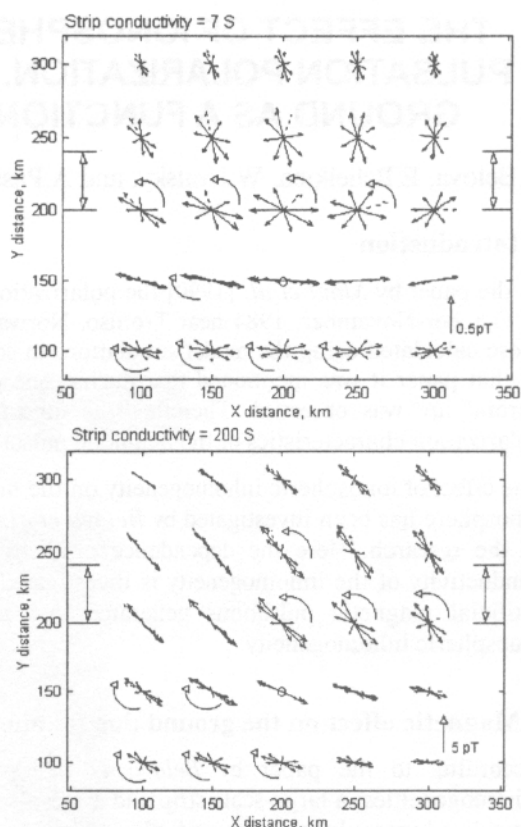


Fig.1. The distribution of the magnetic disturbance vectors calculated for 8 time moments on the ground due to the meso-scale strip for two values of its conductivity $\Sigma_{P2}=\Sigma_{H2}$: 7 S (top) and 200 S (bottom). The coordinates (x,y) of the projection of the source on the ground are equal to (200, 150) km. The projections of the strip borders on the ground are at y=200 km and y=240 km, the position of strip is marked.

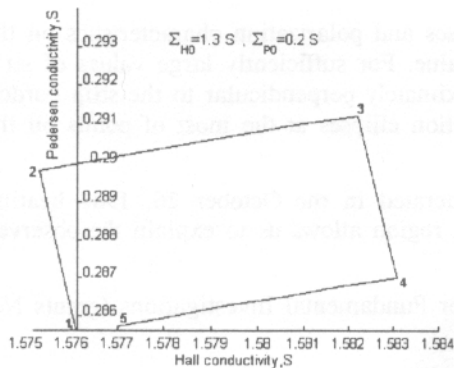


Fig.2. The hodograph of disturbed ionospheric conductivity due to heating of the ionosphere by square-modulated radio wave. The figures 1-5 indicate the time moments during modulation period of the heating wave. The background ionospheric conductivities Σ_{P0} Σ_{H0} are shown. The ionospheric electric field is of the amplitude of 50mV/m. The heating wave has the frequency of 3.324 MHz, the modulation period of 1 seconds, the effective radiated power of 240 MW and ordinary polarization.

Fig.4 presents the distributions of hodographs of the total magnetic disturbance on the ground for the source being near the strip. In comparison with distribution in Fig.3 we have: presence of the strip causes the turn of a major axis of the polarization ellipses toward the perpendicular to the strip border, and the ellipticity of these ellipses decreases.

At the observation point the angle Φ_0 between major half axis of ellipse and eastward direction was observed to be equal to about $+53^\circ$ (plus sign means counter-clockwise) and ellipticity ϵ was about 0.33. Our calculations show that for the horizontally homogeneous ionosphere we have got the value of $\Phi_0 \approx 20^\circ$ and the value of ellipticity of 0.84 (these values differ from those obtained by Maul *et al.* (1990) because they didn't take into account the polarization current). The strip near the source region can give the value of angle Φ_0 up to $+50^\circ$ and the value of ellipticity up to 0.6. Thus the presence of auroral arc near the heated region can explain the observed value of Φ_0 and gives the right tendency (decrease) in behavior of ellipticity.

5. Results

1. For small values of strip conductivity the magnitude of maximum magnetic effect on the ground due to inhomogeneity is larger for the wide strip than for the narrow one, but starting from some value of conductivity the situation becomes inverted.

2. For the wide strip the distribution of magnetic polarization ellipses on the ground due to inhomogeneity is symmetrical relative to the strip border and the line perpendicular to this border and crossing the point that is the

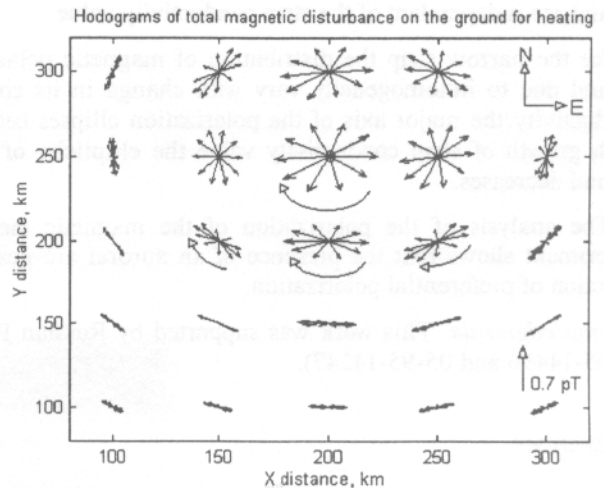


Fig.3. The distribution of the total magnetic disturbance vectors on the ground calculated for 10 time moments during the modulation period of the heating wave. The values of background ionospheric conductivities Σ_{H0} and Σ_{P0} are equal to 1.3 S and 0.2 S correspondingly. The position of the projection of the source on the ground is at (200, 250) km.

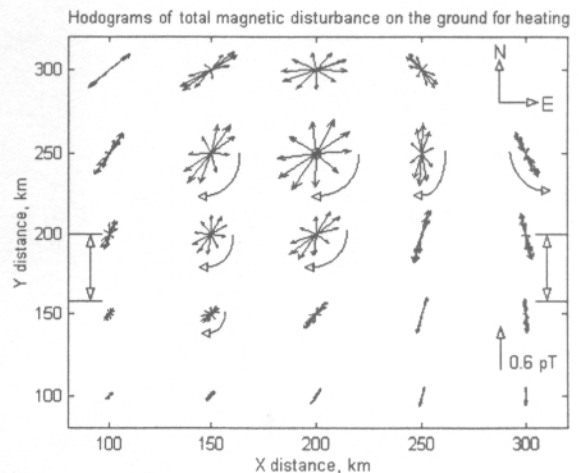


Fig.4. The distribution of the total magnetic disturbances on the ground. The strip conductivities Σ_{H2} and Σ_{P2} are equal to 126 S and 23 S correspondingly. The projections of the strip borders on the ground are at $y=160$ km and $y=200$ km.

projection of the source point on the ground. The polarization characteristics of the magnetic disturbance on the ground are independent of the strip conductivity value.

3. For the narrow strip the distribution of magnetic polarization ellipses and polarization characteristics on the ground due to inhomogeneity vary with change in its conductivity value. For sufficiently large values of strip conductivity the major axis of the polarization ellipses becomes approximately perpendicular to the strip border. With growth of strip conductivity value the ellipticity of the polarization ellipses at the most of points on the ground decreases.

4. The analysis of the polarization of the magnetic disturbance generated in the October 26, 1984 heating experiment shows that the presence of an auroral arc near the heated region allows us to explain the observed direction of preferential polarization.

Acknowledgments. This work was supported by Russian Foundation for Fundamental Investigations (grants No. 05-95-14496 and 05-95-14247).

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