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MEASUREMENTS OF THE MAGNETIC FIELD IN THE VICINITY OF THE MOON ON THE AMS LUNA-10

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The investigation of the intensity of the magnetic field in the vicinity of the Moon has been investigated. During the observation period was measured the regular field, of which the intensity by modulus and components was within the following limits: $T = 23\text{-}40\gamma$; $T_{\parallel} = 18\text{-}38\gamma$; $T_{\perp} = 12\text{-}16\gamma$.

A correlation has been established between the intensity T and particularly $T_{\parallel}$ of the near-lunar field and the index of magnetic activity on the surface of the Earth by analogy with the identical correlation with the intensity of interplanetary fields.

No field of dipole nature and field variation according to a more rapid law has been revealed, that would have taken place at nonuniform magnetization of the Moon.

No Earth's magnetic tail was detected. The possible value of the magnetic tail at the distance of $60R_E$ does not exceed 5γ.

The most reliably measured quantity $T_{\perp}$ constitutes, as an average 15γ, which exceeds the interplanetary fields in free space for the same indexes of magnetic activity. The explanation should be searched for in the perturbing action of the Moon having a certain effective conduction and magnetic permeability. Some of the indicated questions may be refined during measurements on the far side of the Moon.

Author

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* IZMERENIYA MAGNITNOGO POLYA V OKRESNOSTI LUNY NA ISKUSSTVENNOM S°UTNIKE LUNA-10

Measurements of the intensity of the magnetic field in the vicinity of the Moon from the first artificial satellite of the Moon were completed during the period from 3 April to 4 May 1966. This was performed in the course of separate communication sessions on visible portions of the orbit with the help of a three-component ferrosonde magnetometer. The measurement range was of 50γ ($1\gamma = 10^{-5}$oe) over each component, and the threshold response to magnetic field variation was 1γ.

Spinning over a certain axis was imparted to the satellite during its orbital motion. According to magnetometer readings were determined: the intensity modulus of the total magnetic field vector T and of its component along the rotation axis $T_{||}$ and perpendicularly to that axis $T_{\perp}$. The error of the component T on account of the error in the determination of the zero point of the magnetometer and of magnetic deviation may have constituted $\pm 10\gamma$ in its absolute value. The component $T_{\perp}$ did not depend on the zero shift and the magnetic deviation and its error constituted $\pm 2\gamma$. The total measurement error of the absolute value of the modulus of T is estimated to be a quantity of the order of 10γ. The error in the determination of the relative variations of the modulus of T is near $\pm 5\gamma$.

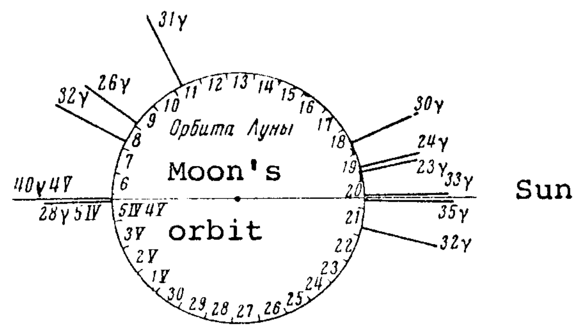


Fig.1

The mean values of the scalar magnitude of the magnetic field T in the days of observations and the corresponding positions of the Moon relative to the line Earth-Sun are represented in the Fig.1. During the entire period of measurements the field intensity by modulus and components was within the following limits: $T = 23 \div 40\gamma$, $T_{\perp} = 12 \div 16\gamma$, $T_{||} = 18 \div 38\gamma$. In their absolute values the measured values of the field are in accord with the estimate of the upper field in the immediate vicinity of the Moon performed during the flight of the second Soviet cosmic rocket [1].

Analysis of the character of the magnetograms during all the observation days and the field component ratios $T_{||}$ and $T_{\perp}$ allowed to establish that during the period of observation the magnetic field in the vicinity of the Moon had a uniform structure and varied little in direction during the displacement along the orbit from pericenter to apocenter.

The observed field may constitute the sum of Moon's proper field and of interplanetary fields of solar origin. During full-moon days the magnetic field of the magnetosphere "tail" may possibly add up to these fields [2, 3]. When discussing the nature and the possible sources of the observed magnetic field it is necessary to bear in mind the following circumstances characterizing the cosmic environment of the experiment:

a) During the entire period of observations sunspots and magnetoactive regions on the Sun were observed only in the northern hemisphere of the Sun with prevailing southern magnetic polarity in the master spot. According to the existing viewpoint the interplanetary magnetic field had then a radial component oriented at the Sun.

b) During the period of magnetic field measurements on the satellite LUNA-10 mainly small variations of geomagnetic activity index were observed: K was equal to $1 \div 3$ and only during the second fullmoon period (4 May), K = 4 during the observation session.

c) During fullmoon periods the Moon is located to the north of the ecliptic plane, where run the "southern" lines of force of the geomagnetic field, which also are then directed at the Sun.

A. <u>Variability in Time of the Near-Lunar Field</u>

There is observed a correlation in the sign of magnetic field variation in the vicinity of the Moon and the index of magnetic activity on the surface of the Earth. This conclusion is derived at comparison of the modulus of T and field components $T_{\parallel}$ and $T_{\perp}$ in the fullmoons of 5 April (T°_1) and 4 May (T°_2): $T^{\circ}_1 - T^{\circ}_2 = -12\gamma$; $T^{\circ}_{\parallel} - T^{\circ}_{\parallel} = -13\gamma$ $T^{\circ}_{\perp 1} - T^{\circ}_{\perp 2} = 0$; for these days $\Delta K = -3$ ($\Delta K = K^{\circ}_1 - K^{\circ}_2$).

The accord in sign between the variation of the index K of magnetic activity on the Earth's surface and the variation of the near-lunar field is preserved also at comparison with measurements during new moon on 20 April ($T^{\bullet}$): $T^{\circ}_1 - T^{\bullet}_2 = -6\gamma$; $T^{\circ}_{\parallel 1} - T^{\bullet}_{\parallel} = -5\gamma$; $T^{\circ}_{\perp 1} - T^{\bullet}_{\perp} = -2\gamma$. Correspondingly $K_1 - K^{\bullet} = -2$.

The greatest changeability at variation of K is revealed by the longitudinal component of the field $T_{\parallel}$. On 19 April $T_{\parallel} = 18\gamma$ (K = 2) on 4 May $T_{\parallel} = 38\gamma$ (K = 4).

It is well known that the intensity variation of interplanetary fields correlates with the variation of the index of magnetic activity [4]. It is natural to assume that in the observed near-lunar field these fields constitute precisely the essential fraction. The sign constancy of the observed near-lunar field is 4 to 6 times greater than that of interpanetary fields in free space. Such a substantial difference should be ascribed to the influence of the Moon. This influence may have a distinct nature.

B. Possibility of Existence of the Moon's Proper Magnetic Field

The possibility cannot be excluded that the Moon may have had in the past a sufficiently intense magnetic field, while preserving at the present time at least a remnant magnetization in its rocks. By analogy with the Earth it may admitted in such a case that this magnetization is closer to the axis of rotation than to the equatorial plane. It may be also admitted that the Moon had no proper magnetic field close to the axis and that it was magnetized under the action of solar magnetic fields, whose intensity and sign differ from those of interplanetary fields at time of measurement. In both these cases it should be referred to the proper magnetic field of the Moon.

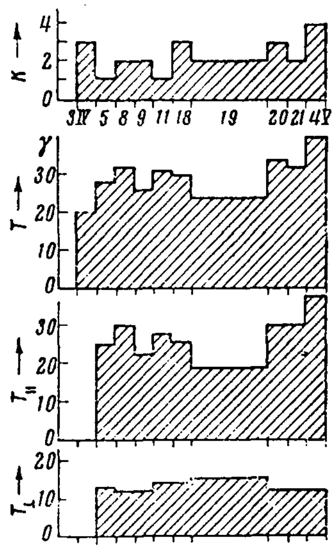
Since the orbit of LUNA-10 was inclined at 72° to the Moon's equator, it might be expected in the first case that at displacement from pericenter to apocenter the field would vary substantially along the direction. This was not observed during the session of 5 April. Besides, at dipole law the field should have varied at such a displacement by a factor of 1.8. In reality the field attenuated from 28γ to 27γ, while the field vector angle with the axis of rotation β varied only by 4°.

At magnetization in a direction close to Moon's equatorial plane, change in the field's sign should have been expected at variation of lunar longitude from session to session. Such a sign change was not observed. Therefore, observations on AMS LUNA 10 failed to reveal the presence of a Moon's proper magnetic field of dipole nature and notable intensity. The significant excess of the near-lunar field over the intensity of interplanetary fields in free space may possibly be linked with field deformation by the Moon, having a finite conduction and a notable magnetic permeability of its rocks.

In the first case the principal role must be played by the mechanism of magnetohydrodynamic flow of plasma and fields past the Moon's body. For the explanation of significant deformation of interplanetary fields owing to statical magnetization of lunar rocks, we must admit that the rocks of the lunar surface have a magnetic permeability $\kappa \approx 0.5$, which is little probable.

C. Field of the Earth's Magnetic Tail

According to theoretical estimates [2, 3], on the night side the magnetic field of the Earth may extend to $100R_E$ (R_E being the radius of the Earth).. The effect of the Earth's magnetosphere tail may be made evident by comparison of magnetometer readings during the fullmoon T° and new moon T periods under the condition of identical level of magnetic activity. As already mentioned, this last condition was not fulfilled and a correlation was established between the field intensity and the index of magnetic activity. Comparison of the field at new moon of 20 April and the second fullmoon of 4 May gives $T^{\circ}_{2} - T^{\bullet} = +6\gamma$; $T^{\circ}_{\parallel 2} - T^{\bullet} = +8\gamma$; $T^{\circ}_{\perp 2} - T^{\bullet} = 2\gamma$. By comparison with the first fullmoon the differences changed signs in complete correspondence with the sign of the difference ΔK.



Fig/2

The mean values of the field T and of the components $T_{\parallel}$ and $T_{\perp}$ for three days near the first fullmoon, that is on 5, 8, 9 April, and near the new moon, i. e., on 19, 20, 21 April, do not provide notable difference

$$T^{\circ}_{1} - T^{\bullet} = -2\gamma;$$
$$T^{\circ}_{\parallel 1} - T^{\bullet}_{\parallel} = 0;$$
$$T^{\circ}_{\perp 1} - T^{\bullet}_{\perp} = -2\gamma.$$

The mean values of K for the new moon days somewhat exceeded the mean K for the fullmoon. $K^{\bullet} = 3.3$; $K^{\circ} = 2.7$. Consequently, the effect of the Earth's magnetosphere tail is lower than the effect of variations of the interplanetary field. It may be concluded that in the given experiment by direct magnetic measurements, the extension of the tail of the Earth's magnetosphere to distances of 60 R_E is not established.

The final conclusions, in the number of five, derived from the present work, have been presented in the forward abstaact.

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**** T H E E N D ****

I Z M I R A N

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