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SIGNS OF CROSSING BY THE MOON OF THE EARTH'S MAGNETOSPHERE TAIL ACCORDING TO DATA OF CHARGED PARTICLE TRAPS ON THE FIRST ARTIFICIAL SATELLITE OF THE MOON

(LUNA-10)

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SUMMARY

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The results presented in this paper are based only upon the preliminary data, conducted with the first two traps. Even these stem from still unfinished measurements.

The main conclusions derived are evidence that during the experiments the Moon, alongside with its satellite, emerged from the tail of the Earth's magnetosphere in which there are electron fluxes with $E_e > 70$ ev, and then, as the May fullmoon approached, entered that tail again. Therefore, the distance from the Earth in the antisolar direction, over which signs of magnetosphere existence are observed on the basis of measurements considered, increases from ~200 000 km, according to data from IMP–1, to ~380 000 km according to data from LUNA–10.

Author

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Space probe LUNA–10 was launched on 31 March 1966 and placed into an orbit around the Moon on 3 April 1966, having thus become the first artificial satellite of the Moon. Alongside with other scientific devices, four charged particle trpps were installed on board LUNA–10, disposed as indicated by (Л) in Fig. 1.

Among them were two plane four-electrode traps registering aggregate fluxes of electrons with energies $> E_e = 70$ ev and of positive ions with energies $> E_p$. The quantity E_p was determined by the voltage on the second grid of the trap, which varies once in 2 min. from 0 to 50 v. Accordingly varied also the quantity E_p from the value determined by the potential of the satellite φ_s, to ~50 ev. The angle between the normals to trap collectors constituted 156°.

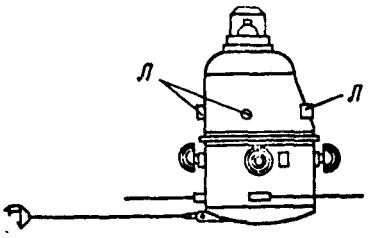

Fig. 1

* PRIZNAKI PERESECHENIYA LUNOY KHVOTA MAGNITOSFERY ZEMLI PO DANNYM LOVUSHEK ZARYAZHENNYKH CHASTITS NA PERVOM ISKUSSTENNOM SPUTNIKE LUNY

These traps were a modification of those utilized for the registration of soft electrons of the near-ground space and solar plasma fluxes in the interplanetary space on the first lunar rockets in 1959 [1].

The third trap, of the modulation type, was destined for low-energy positive ions; the fourth trap registered the aggregate current induced by electrons and positive ions in the cases when this current was negative; registered in it were electrons of all energies for $\varphi_s \geqslant 0$ and with energies $E \geqslant |\varphi_s|$ at $\varphi_s < 0$; positive ions with energies ~20 ev could hit the trap's collector.

In the present communication we utilized only the data of preliminary measurements, conducted wuth the help of the first two traps.

As was shown by a serees of measurements during the last years, and particulary by the magnetic measurements of N. F. Ness, carried out in 1963-64 on the satellite IMP-1 [2], the region of the regular geomagnetic field (magnetosphere) is extremely elongated in the antisolar direction as a result of interaction of solar plasma fluxes (solar wind) with the geomagnetic dipole. Measrrements by Ness have shown that the elongated in the antisolar direction part of the magnetosphere ("magnetosphere tail") stretches in any case to distances of $\sim 30 R_E$ from the Earth (R_E being the Earth's radius). Despite the fact that various authors ventured different assumptions about the extension of the magnetosphere tail (including the assumptions, whereby it attains several tens of astronomical units [3]), direct experiments, giving demonstration of the existence of magnetosphere tail exceeding $30 R_E$ in length, have to-date been absent.

Such experiments may be not only direct measurements of the magnetic field in the region being the extension of the earlier investigated part of the magnetosphere tail, but also measurements of charged particle fluxes in that region.

There must exist in the magnetosphere tail fluxes of plasma. Indeed, the configuration of the magnetic field in the tail is entirely different from the dipole field, and it may be induced only by a system of currents for the existence of which the presence of charged particles is prerequisite. Only owing to plasma flux can this region of the magnetosphere be steady; note, as was shown by Ness [2], that the values of electron fluxes with energies $E_e > 200$ ev, measured near the Earth on LUNA-2 [1], agree with the data of measurements on IMP-1. However, the unperturbed solar wind cannot penetrate inside the magnetosphere; on the other hand, one of its peculiarities consists in that electrons with energies exceeding 20-30 ev are practically absent in it. Consequently, in the unperturbed interplanetary space the traps, in which electrons with energies > 70 ev decelerate, must not register electron fluxes. At the same time, one may expect that fluxes of electrons with $E_e > 70$ ev do exist in the magnetosphere tail, and thus may be registered by such traps. This may be utilized to determine, according to data of traps, where the space probe is located, in the Earth's magnetosphere or beyond it.

LUNA-10 was launched on 31 March 1966, period close to fullmoon. We have schematically indicated in Fig. 2 the projection of its trajectory in the ecliptic plane, and also the boundaries of the magnetosphere after Ness;

the magnetosphere is shown to be symmetrical relative to the line Sun-Earth. Dashes indicate the assumed extension of magnetosphere boundary in a region, in which direct magnetic and plasma measurements were earlier absent; certain radiocommunication sessions with Luna-10 are indicated by rectangles, and measurements were conducted only during these sessions.

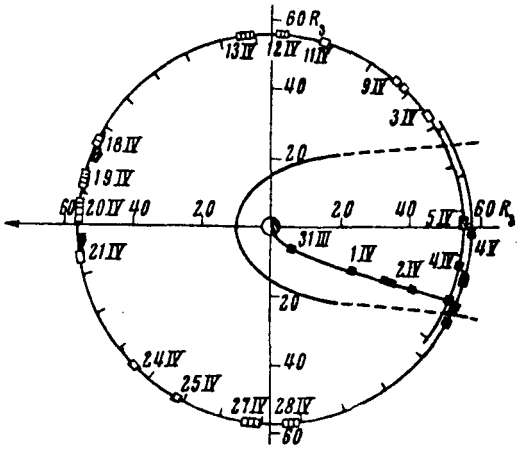

Fig. 2

It may be seen from Fig. 2 that the entire trajectory Earth Moon lay in the Earth's magnetosphere tail and its extension.

The preliminary study of the results of measurements of fluxes in two traps, registering the differences of fluxes of positive ions with E > 50 ev and electrons with E > 70 ev for the period from 31 March to 5 May has shown that all the measurement sessions can be subdivided in two groups. Negative currents were measured at least in one of the two considered traps, in the course of the first session; during the sessions of the second group only positive ions were measured.

We refer to the first group all the measurement sessions performed when LUNA 10 was located inside either an earlier known part of magnetosphere tail, or its extension (of which the limits are shown in Fig. 2 by dashes.

In Fig. 3 we have indicated by clear circles for one trap, and by dark circles for the other, the currents during parts of the three session of this group; the session of 2 April was conducted over the path from Earth to Moon (see Fig. 2); the session of 5 April — over the near-lunar orbit in a period close to fullmoon after the Moon has comple a full convolution around the Earth. The scattering of the values of currents is linked with the variations of satellite orientation. Apparently, the negative currents correspond in these sessions to really existing fluxes of electrons with E > 70 ev, and are not induced, for example, by photoemission, for cases are observed of simultaneous registration of nearly identical negative currents in both traps (during the session of 2 April, only negative currents were registered). However, in these sessions currents of opposite signs were observed in these traps substantially more often. Inasmuch as the normals to collectors of these traps constitute an angle of 156°, i. e., the traps are disposed nearly diametrically opposed, one is led to believe that this is evidence of the presence of electric current in this region.

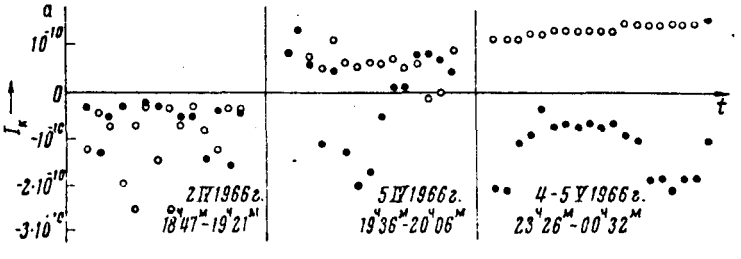

Fig. 3

Related to the second group are the measurement sessions conducted when the Moon (and consequently also its satellite) were knowingly beyond the Earth's magnetosphere (clear rectangles of Fig. 2). The positive currents, registered during these sessions by the traps, rise by comparison with the sessions of the first group, whereupon in certain cases, as, for example in the session of 9 April shown in Fig. 4, the rise attains one order of magnitude.

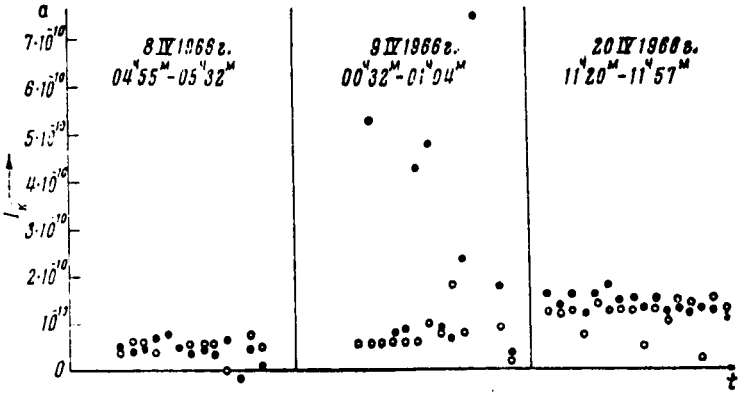

Fig. 4

As already noted, practically no negative currents induced by electrons with E > 70 ev are registered in the traps under consideration, as must be in the unperturbed solar wind. However, in the traps oriented in the nearly opposite direction, fluxes of positive ions with E > 50 ev are simultaneously observed. This cannot take place in unperturbed fluxes of plasma, radially propagating from the Sun. Apparently near the Moon, when it is beyond the Earth's magnetosphere tail, a perturbed zone is formed, in which there are fluxes of positive ions with energies E > 50 ev, moving in a direction not coinciding with that of the solar wind, and the orbit of the first artificial satellite of the Moon passes inside that perturbed zone.

As was shown during our acquaintance with the ground magnetograms of the geomagnetic field (Moscow, Krasnaya Pahra), all the days for the period from 31 March to 15 April were magnetoquiet to an equal degree, and this is why there is no basis to relate the variation in the character of the currents registered in the traps with the variation of the structural parameters of the solar plasma fluxes in the region of Moon's orbit.

All measurements referred to the first group of sessions were completed either in an earlier known part of the magnetosphere tail (31.March), or in its extension (3, 4 and 5 April and 4 and 5 May); all measurement sessions of the second group were knowingly performed beyond the Earth's magnetosphere. This attests to the fact that during the experiments conducted, the Moon (together with its satellite) emerged from the magnetosphere tail, in which there exist fluxes of electrons with energies E > 70 ev, and then, as the May fullmoon drew nearer, it again reintered the Earth's magnetosphere tail.

Thus, the distance from the Earth in antisolar direction, over the extent of which there are observed according to measurements considered indices of the presence of the magnetosphere, increased from ~ 200,000 km according to data from IMP-1 to ~ 380,000 km according ot the data of LUNA-10.

It should be borne in mind that measurements are not completed as yet. A more complete analysis, including the data obtained after the present note has been completed), and also the measurements with the aid of the other two traps, will be published later.

*** THE END ***

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