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# DIRECT OBSERVATIONS OF SOLAR PLASMA STREAMS AT A DISTANCE OF ~ 1 900 000 KM FROM THE EARTH ON FEBRUARY 17, 1961, AND SIMULTANEOUS OBSERVATIONS OF THE GEOMAGNETIC FIELD

K. I. GRINGAUZ, V. V. BEZRUKIKH, S. M. BALANDINA,
V. D. OZEROV and R. E. RYBCHINSKY

**Abstract:** Final results are presented of the processing of the data of the experiment aimed at investigating solar plasma streams from the Venus probe launched on February 12, 1961.

Preliminary results were reported by K. I. Gringauz at the Second International Space Science Symposium in Florence in 1961.

The results are compared with the geomagnetic field simultaneous observations.

**Резюме:** Представлены окончательные результаты обработки данных опыта по исследованию потоков солнечной плазмы на автоматической межпланетной станции, запущенной в направлении к Венере 12 февраля 1961 г. Предварительные результаты были сообщены К. И. Грингаузом на Втором Международном симпозиуме по изучению космического пространства во Флоренции в 1961 г. Результаты сравниваются с данными одновременных наблюдений геомагнитного поля.

In K. I. Gringauz' report at the Space Science Symposium in April 1961 in Florence [1] the preliminary information was given on the results of the experiment carried out by means of charged particle traps on the Soviet Venus probe launched on February 12, 1961. In the present report final, somewhat corrected results of measurements are presented. They are compared with the results of the simultaneous registration of the geomagnetic field variations on the Earth.

Let us remind that at the said probe two three-electrode traps were installed among the scientific instruments. They differed only by some design changes from the traps mounted on Lunik II by means of which in 1959 solar plasma streams were recorded for the first time outside the geomagnetic field [2]. The changes introduced into the design were directed to the reduction of its weight and further decrease of the collector current component produced by the photoelectron and secondary emission from the inner grid of the trap.

The potentials of the outer grids of the traps on the Venus probe were $\varphi_{g2}'=0$ and $\varphi_{g2}''=+50$ volts. During the measurements the traps retained definite orientation with respect to the direction to the Sun and to the velocity vector due to which collector current variations caused by the body rotation described in [2] and [1] could not take place.

Fig. 1 gives the results of the measurements of the trap collector currents during three radiotelemetry transmissions from the Venus probe. Table 1

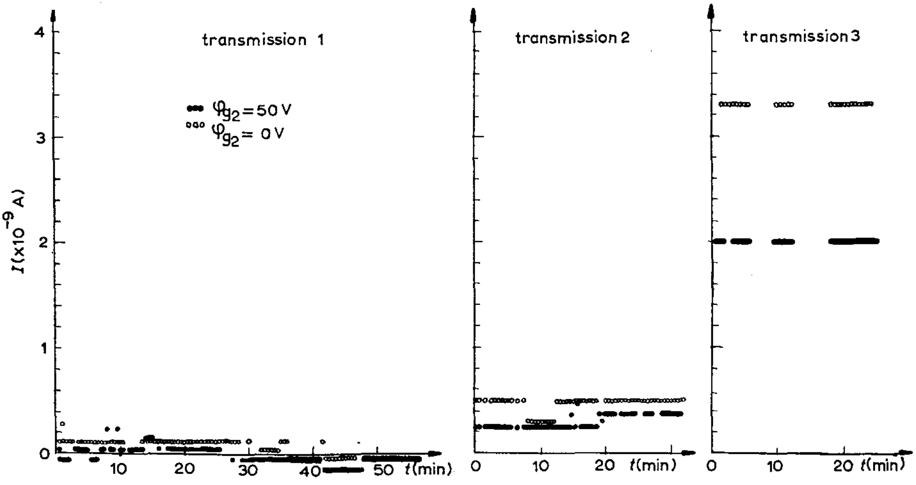


Fig. 1.

gives the time $t$ of the beginning of each of these transmissions and the distance $R$ of the probe from the Earth's centre which corresponds to the beginning of each of these transmissions and the distance $R$ of the probe from the Earth's centre which corresponds to the beginning of the radio contact.

TABLE 1

| No. of transmission received | $t$ (Moscow time) | $R$ (km) |
|---|---|---|
| 1 | 12.II.1961 6h 45m | 30 000 |
| 2 | 12.II.1961 14h 25m | 170 000 |
| 3 | 17.II.1961 14h 35m | 1 900 000 |

While considering fig. 1 one should bear in mind that the collector current amplifier of the trap with the outer grid potential equal to 0 had a characteristic which consisted of two linear portions. The slope of the upper portion was comparatively low. The maximum measured current was close to $8\times 10^{-8}$

amperes. The trap collector current amplifier with $\varphi_{g2} = +50$ volts has a characteristic close to linear one. The maximum measured current was equal to $2 \times 10^{-9}$ amperes.

As it should be expected the collector current modulation, which took place in previous similar experiments, was absent in this case, as is evident from the graphs of fig. 1.

Let us note that the recorded currents are somewhat lower than those determined by the positive ion fluxes get into the trap at the expense of the currents produced by the emission of photoelectrons from the inner grid. However, from the materials given in [1] and [2] it can be seen that the photocurrent from the inner grid in the traps on the first space probes did not exceed $5 \times 10^{-10}$ amperes, while in the traps on the Venus probe it was considerably lower, since the inner grid transparency was increased.

During the first reception of signals the currents of both traps oscillated near zero values. The Venus rocket was at distances of 30 000 ÷ 45 000 km from the Earth's centre, i.e. in the outer part of the second radiation belt. The absence of considerably negative collector currents in the traps during the first radio contact testifies once more to the absence in the second radiation belt of soft electron fluxes of the order of $10^{10}$ cm$^{-2}$ sec$^{-1}$ postulated by the majority of the investigators of this belt in 1959–1961. A more detailed consideration of this problem is given in the report by Gringauz, Balandina, Bordovsky and Shutte at the present symposium [3].

During the second radio-contact low positive currents were registered in both traps. Considerably larger currents were recorded in the traps during the third radio contact.

The current of the trap with the outer grid potential $\varphi_{g2} = +50$ volts is equal to $2 \times 10^{-9}$ amperes, i.e. corresponds to the maximum value of the current which could be recorded by the collector current amplifier of this trap. The simultaneous current in the trap with the zero potential on the outer grid is equal to $\sim 3.3 \times 10^{-9}$ amperes. This value apparently determines the $N^+$ value of the positive corpuscular stream which took place during the third radio contact, namely $\sim 10^9$ cm$^{-2}$ sec$^{-1}$. With the accuracy up to the measurements errors the stream value was constant during the third radio contact.

During the third reception of signals a magnetic storm with a gradual commencement took place on the Earth, which started on February 17 about 12 hours Moscow time and lasted for several days.

Fig. 2 presents collector currents graphs in the traps for each radio contact on the same time scale and the results of the simultaneous registration of the magnetic field parameters according to the data of the Central Magnetic

Observatory (Moscow). The latter represent the records of the Lacourt magnetograph recorders which registered the geomagnetic field intensity horizontal component $H$ and the angle of the magnetic declination $D$.

The problem of the correlation between the intensity variations of solar corpuscular stream affecting the Earth's magnetosphere and the geomagnetic field variations during the magnetic storm produced by this stream is not sufficiently clear at present.

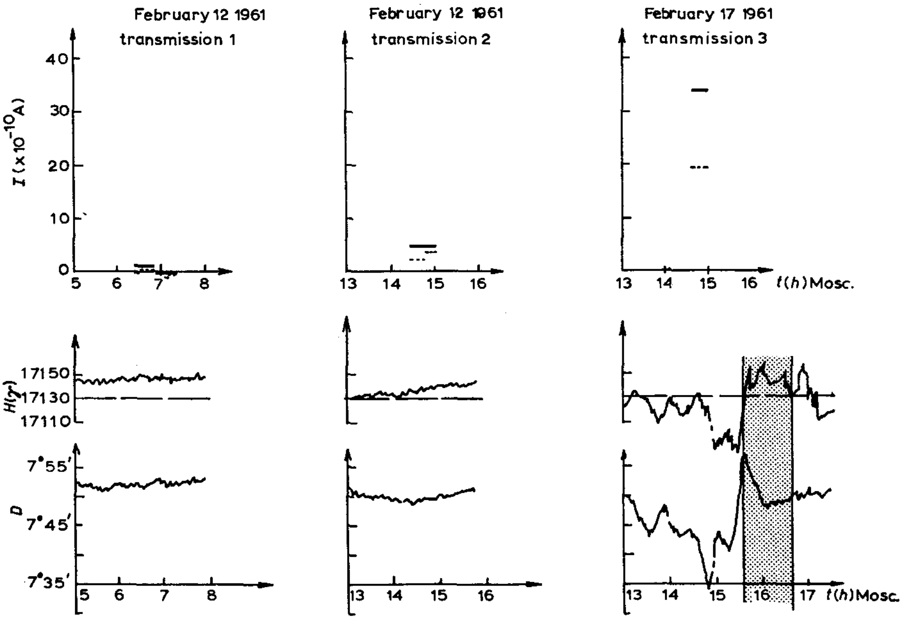


Fig. 2.

Some of the authors believe that for the first hours of the magnetic storm the geomagnetic field fluctuations correspond to the fluctuations of the corpuscular stream and then this correspondence is violated due to the action of the electric current systems which appeared in the ionosphere under the influence of corpuscular streams [4].

This would have been checked up if we had had at our disposal simultaneous long time observations of the corpuscular stream variations in interplanetary space outside the geomagnetic field and of the magnetic field variations on the Earth. Due to the short time (half an hour) duration of the third radio contact the experimental results obtained from the Venus probe have not provided us with such an opportunity.

Nevertheless it is interesting to make an attempt at establishing the correlation between these values assuming that the geomagnetic disturbance value is determined at this time by the corpuscular stream getting into the Earth's magnetic field. It is necessary to take into account that between the moment of the registration of the density of some part of the corpuscular stream on the probe and the moment of the contact of the same part of the stream with the Earth's magnetosphere some time has elapsed determined by the mutual location and mutual velocities of the motions of this part of the corpuscular stream, of the Earth and the rocket.

Fig. 3 presents the mutual location of the Venus probe and the Earth during the third radio contact. The Venus rocket was at a distance of

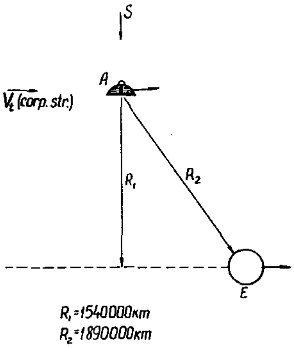


Fig. 3.

1.89 million kilometres from the Earth. The distance from the Sun to it was by 1.54 million kilometres less than the distance from the Sun to the Earth. At the same time it somewhat lagged behind the Earth in its angular motion about the Sun.

It should be borne in mind that the tangential velocity of the corpuscular stream motion at a distance of 1 Astronomical Unit exceeds the Earth's orbital velocity by a factor of 14.

Trying to estimate the delay of the moment of the contact of some region of the stream with the Earth relative to the moment of its contact with the rocket some suppositions about the stream shape should be made. This stream region can come into contact with the Venus probe and then with the Earth by its front (the time $\tau$ of the delay of these phenomena will be determined by the radial velocity of corpuscles), or by its lateral surface (in this case $\tau$ depends also on the stream tangential velocity equal to $\sim$ 400 km/sec). Cases are also possible when this region of the stream comes into contact with the Venus probe by its front and with the Earth by its lateral surface.

The radial velocity roughly estimated from the delay of the moment of the beginning of the magnetic storm relative to the moment of the passage of the active region on the Sun through its central meridian turned to be equal to $\sim$400 km/sec for the storm on February 17, 1961.

Taking into account all these suppositions the time $\tau$ turned to be within the limits of 64–110 minutes. The boundaries of the hatched area in fig. 2 are determined by the moments of the beginning and the end of the third reception of the signals with the lowest and greatest delay time correspondingly taken into account.

In this region and its closest vicinities the H fluctuation reached about 100 gammas.

It should be noted that the value $N^+$ measured by us is close to the maximum value $N^+$ obtained in the experiment by Bridge, Dilworth and others [5] on the Explorer X satellite, and the velocity of corpuscles determined by the indicated indirect method is close to the corresponding mean value directly measured in the experiment [5].

## Acknowledgement

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## References

1. K. I. Gringauz, Space Research II, ed. H. C. van de Hulst *et al.* (Amsterdam, North-Holland Publishing Company, 1961) 539
2. K. I. Gringauz, V. V. Bezrukikh, V. D. Ozerov and R. E. Rybchinsky, Doklady Akad. Nauk SSSR **131** (1960) 1301; Iskusstvennye Sputniki Zemli, The Publishing House of the USSR Academy of Sciences, 101 (1961)
3. K. I. Gringauz, S. M. Balandina, G. A. Bordovsky and N. M. Shutte, See these Proceedings, p. 432
4. V. I. Afanasyeva, Proc. of the Institute for Terrestrial Magnetism, the Ionosphere and Radio Wave Propagation of the USSR Academy of Sciences **12** (22) (1957) 63–67
5. H. S. Bridge, C. Dilworth, A. J. Lazarus, E. F. Lyon, B. Rossi and F. Scherb, Direct Observations of the Interplanetary Plasma, Report at the Kyoto Conference, (September, 1961)