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# Ion and Electron Analysis in Retarding Electric Field for Ionospheric Studies Performed with the Intercosmos-8 Satellite

*K. I. Gringaus, G. L. Gdalevich, V. F. Gubskiy, K. B. Serafimov, S. K. Chapkunov*

## Introduction

The Intercosmos-8 satellite was launched on December 1, 1972. Experiments on this satellite were a continuation of the ionospheric studies initiated by the Intercosmos-2 satellite [1-4] and by the geophysical rockets Vertical-1 and Vertical-2.

Specialists from Bulgaria, the German Democratic Republic, USSR and Czechoslovakia took part in the study.

The initial orbital parameters of Intercosmos-8 were the following: apogee — 679 km, perigee — 214 km, inclination — 71°, and period — 93.2 mm.

The following measurements were carried out:

1. Positive ion density.
2. Electron temperature.
3. Electron density and temperature.
4. Intergal electron density between the satellite and the ground-based radio-receiving stations.
5. Electron fluxes with 40 keV and protons with 1 MeV of energy.

The following scientific equipment was installed on the satellite:

— Sensors of the instruments for ionospheric parameter measurements; semiconducting and gas-discharge counters for high-energy electrons and protons (USSR).

— Instrument for plasma parameter measurements with the help of ion traps and Langmuir probe (Bulgaria).

— "Mayak" radio-emitter and intermediate device for the registration of the Langmuir probe data in the satellite memory (GDR).

— Instrument for measurements of electron temperature with a high-frequency probe (Czechoslovakia).

Specialists from Bulgaria, the German Democratic Republic and Czechoslovakia took part in the technological and launch tests of the above items of equipment. They also took part in the satellite launch.

The experimental data obtained as a result of the measurements carried out on the satellite with the scientific equipment were processed as follows: from the ion traps — in Bulgaria and in the USSR; from the Langmuir probe — in Bulgaria and in the USSR, from the high-frequency probe in Czechoslovakia and in the USSR.

## Information on the Soviet-Bulgarian Probe Experiment with Intercosmos-8

The choice was a satellite with chemical battery, for carrying out the experiments listed above. The purpose was to reduce to the minimum the medium deformation caused by the satellite during the probe measurements. The currents of the solar batteries were apt to generate magnetic fields, despite the precautions taken. Their influence on the measurements of the cold ionospheric plasma local parameters is difficult to be accounted for.

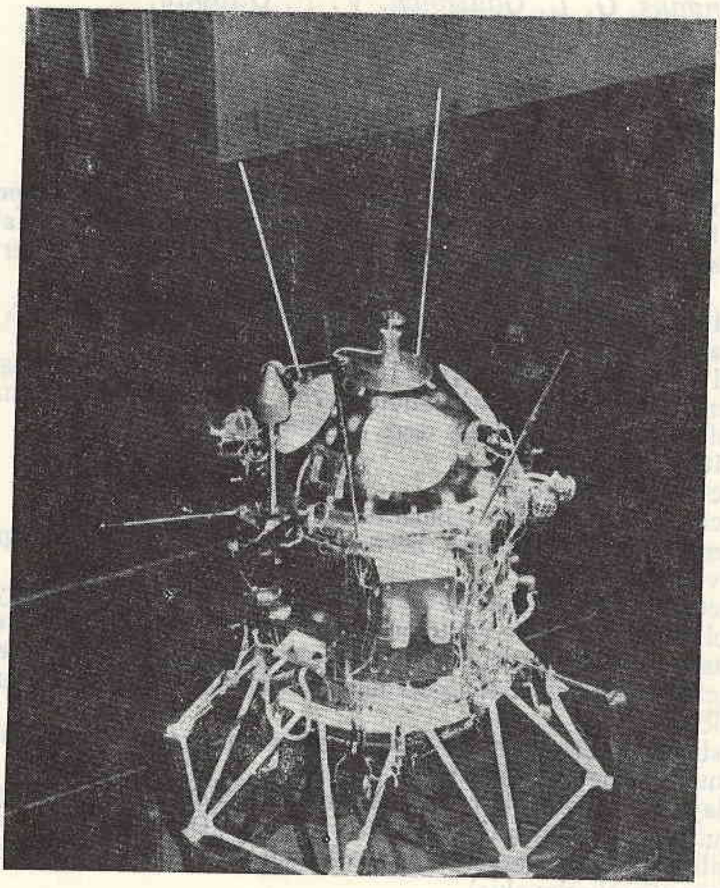

Fig. 1. General view of the Intercosmos-8 satellite

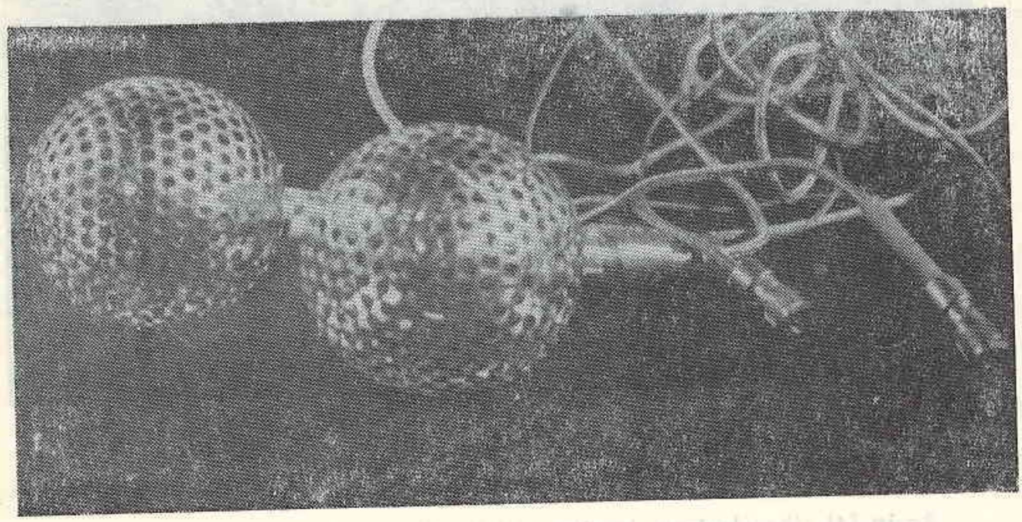

Fig. 2. View of the Intercosmos-8 ion traps

The satellite did not have an orientation system, but it was provided with equipment ensuring the determination of its direction with respect to the magnetic field and the Sun (Fig. 1). As the satellite was not oriented, the ion traps were spherical in shape, which ensured the minimum dependence of the measurement results on the probe orientation. The iron traps were mounted on booms diametrally opposed to one another, so that at any moment one of them could be out of the rarefied zone which was formed in the direction opposite to the satellite velocity vector. The Langmuir probe was mounted on the central cross-section plane of the satellite, perpendicular to the two traps.

The spherical ion traps are the first instruments with which the successful ionospheric study by direct probe techniques had begun and the first distribution of the ionospheric charged particle concentrations had been obtained [6]. Since then, spherical ion traps have been applied on a number of occasions for ionospheric measurements in the Soviet Union and in other countries.

The traps used on Intercosmos-8 (Fig. 2) were 60 mm in diameter and were mounted on booms 500 mm in length, so as to be out of the layer with the bulk electric charge which surrounded the satellite. The collector of each trap was 20 mm in diameter and was enveloped in an anti-photoelectronic grid 26 mm in diameter. A potential of — 100 V with respect to the satellite body was applied to the grids. Isolated voltage of —80 V with respect to the amplifier inputs (see [5]) was applied to the collectors for full ion collection in the internal space of the traps.

A linearly changing voltage, varying from —5 V to +15 V for 6 s with respect to the satellite, was applied to the outer grids of the traps. Much like in the case described in [1], this voltage was applied in turns to the outer envelopes.

The currents measured were commutated in turns to the input of the same amplifier [7], in order to reduce the indeterminateness introduced by the drift of the different DC amplifiers, and also to reduce the energy source, the weight and the number of the telemetric channels necessary for data broadcasting.

The determination of the positive ion density was accomplished by the technique suggested in [6], i. e. along the slope of the volt-ampere curve.

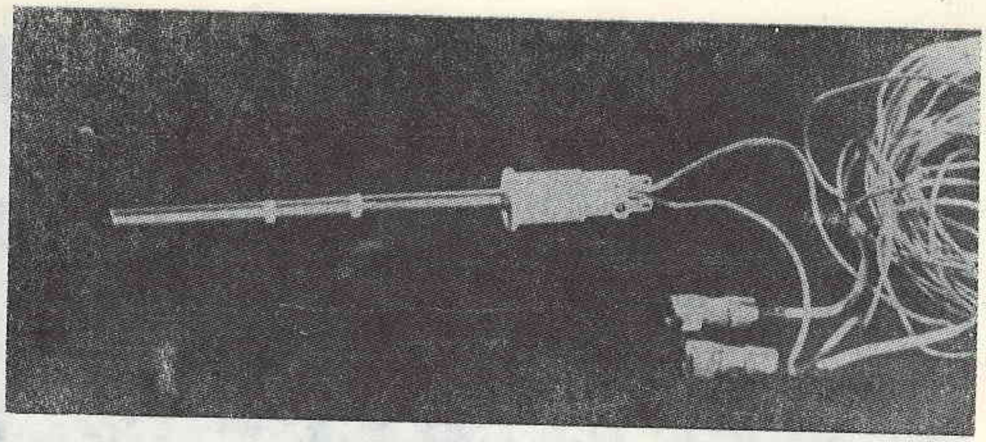

Fig. 3. View of the Intercosmos-8 Langmuir probe

As in [4], the electron density and the temperature were measured by the method of the Langmuir probe. Only one cylindrical Langmuir probe was mounted on the Intercosmos-8 satellite (Fig. 3). The probe was detached from the satellite body by a boom 500 mm long.

The probe (Fig. 3) was 6 mm in diameter and 20 mm long, and it was positioned between two protective sections. The overall length of the probe and of the protective sections was 110 mm. The probe voltage varied from — IV to +4 V in 1 s.

Unlike in the case of the Intercosmos-2 experiment, the present measurements of the electron temperature and density, made with the Langmuir probe were carried out not only during the direct radiotelemetric connection with the ground-based receiving stations, i. e. in the zones of the direct visibility of the satellite, but also out of the limits of these stations.

By means of the satellite memory device the Langmuir probe operated in memory-regime, and this made it possible to retain the measurement results during the full satellite turn around the Earth, followed by informational emission effected by the telemetric communication line.

The ion trap data were also recorded during the satellite flight out of the visibility zone of the receiving radiotelemetric station.

## Brief Characteristics of the Recorded Information

The operation of the satellite equipment continued for almost two months, and during that time it was possible to have a number of direct radio-communication seances, as well as reproduction of the information kept by the memory device during the full satellite turns of the Earth.

The results from the probe measurements of the local parameters $n_e$ (or $n_i$) close to the satellite, together with the data from the ground observations on coherent radiowaves, can be used for the determination of the vertical distribution $N(h)$ up to the satellite altitudes. Records of the volt-ampere characteristics are given below.

The records of the telemetric control on the saw-tooth voltage applied to the trap envelopes, as well as the volt-ampere characteristics of the iron traps, are shown on Fig. 4. During the first six seconds we recorded the collector current of the trap, to the outer envelope of which a linearly changing voltage was applied, and the envelope of the other trap was simultaneously provided with a potential of —5V with respect to the satellite body. The second trap operated during the following 6 seconds, and the outer grid of the first trap was provided with a potential of —5 V. In this manner we can see both spherical traps in operation on the same record, and this facilitates the processing of the results of the experiment.

Figure 5 shows records of the telemetric control of the saw-tooth voltage which is applied to the collector and of the protective electrodes of the Langmuir cylindrical probe, as well as a record of the volt-ampere characteristics of this probe under conditions of direct data transmission.

Records of the telemetric control of the linearly changing voltage, and volt-ampere characteristics of the Langmuir probe are shown in memory regime on Fig. 6. The saw-tooth voltage generator [5] is controlled under these conditions

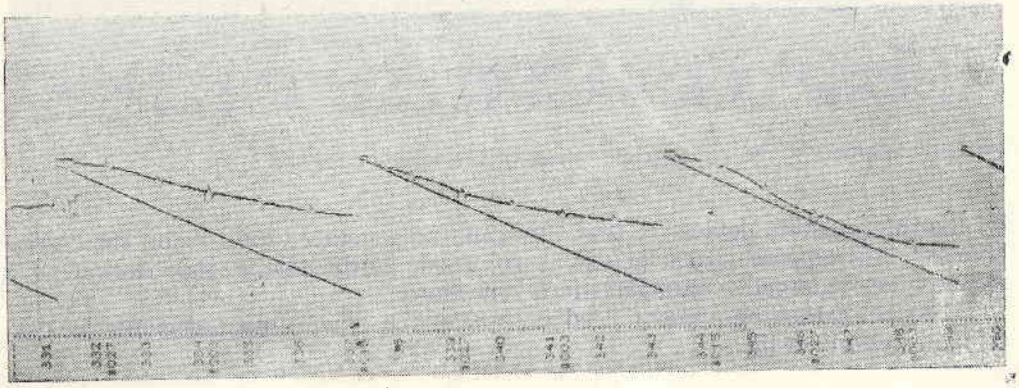

Fig. 4. Ion traps telemetric records

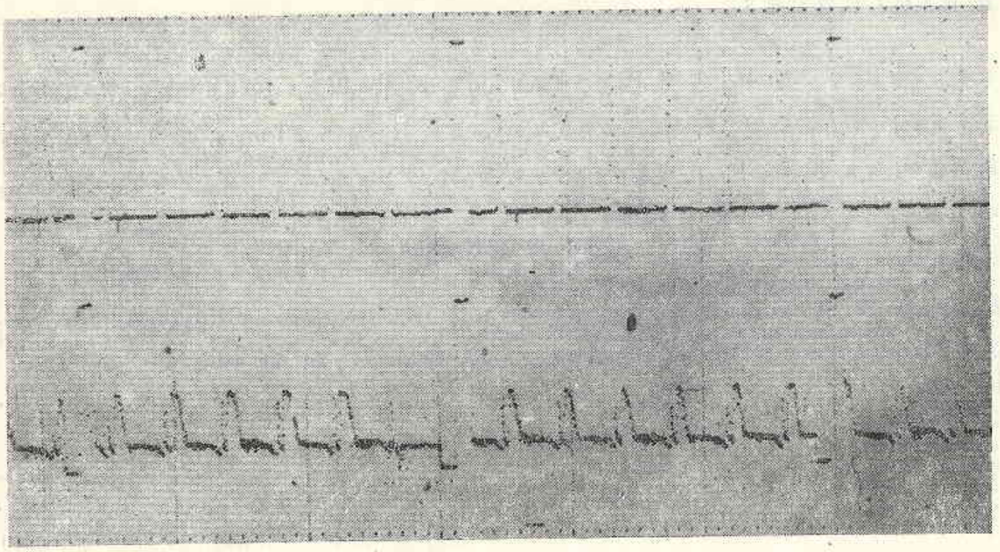

Fig. 5. Langmuir probe records in real time telemetry

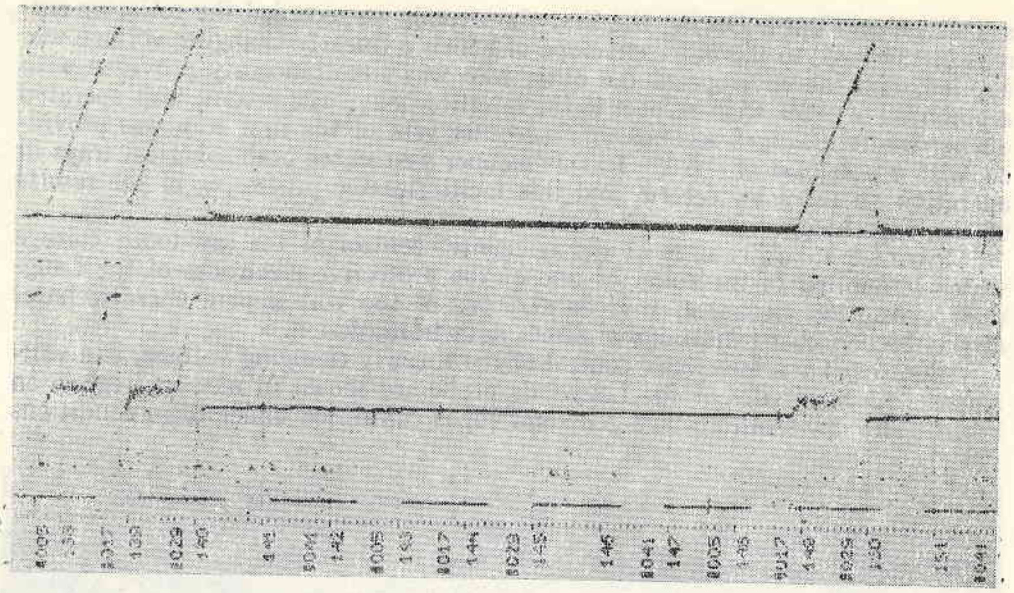

Fig. 6. Langmuir probe telemetric records in the memory regime

by the intermediate device, so that the scanning generated for 1 s and the corresponding volt-ampere characteristic is recorded, while during the following 8 seconds the "enlarged" characteristic is reproduced.

The Bulgarian equipment used in taking the above measurements is described in detail in [5].

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# Исследование структурных параметров ионосферы методом анализа ионов и электронов в запирающем электрическом поле, проведенное при помощи ИСЗ „Интеркосмос-8"

*К. И. Грингауз, Г. Л. Гдалевич, В. Ф. Губский,*
*К. Б. Серафимов, С. К. Чапкынов*

(Р е з ю м е)

Вкратце перечислены эксперименты и реализирующие их аппаратуры, включенных в состав спутника „Интеркосмос-8".

Рассмотрены зондовые эксперименты для исследования электронной концентрации и электронной температуры, реализуемые с помощью цилиндрического зонда Ленгмюра, и для исследования ионной концентрации и ионной температуры (в определенных границах) с помощью трехэлектродных сферических ионных ловушек.

Показаны характерные регистрограммы исследуемых параметров, полученных по телеметрическим каналам, обслуживающим советско-болгарский зондовый эксперимент. Вкратце рассмотрены некоторые особенности телеметрической записи в этом первом космическом эксперименте с участием Центральной лаборатории космических исследований Болгарской академии наук.