LOW-FREQUENCY SOLAR RADIO BURSTS OBSERVED WITH THE "INTERCOSMOS-KOPERNIK 500" SATELLITE

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Abstract: The report contains a short description of the first Soviet-Polish space experiment, which has been accomplished on board of the "Intercosmos-Kopernik 500" satellite, launched to commemorate the 500 Anniversary of the Copernicus birth. The purpose of the experiment among others is to observe sporadic radio emissions generated in the coronal and interplanetary medium at hectometric wave-lengths range.

The idea of the experiment is presented together with the brief description of the satellite, measuring equipment and data reduction. Several slides illustrate the experiment as well as the equipment.

Some examples of low-frequency solar radio bursts obtained during "Intercosmos-Kopernik 500" flight are shown.

Introduction

One of the space experiments, carried out aboard the Soviet-Polish satellite "Intercosmos-Kopernik 500", launched this year to commemorate the 500th anniversary of Copernicus birth was aimed at studying low-frequency solar radio bursts, generated in the upper layers of the corona.

The initial elements of the orbit for the initial day of 19th April 1973 were 1551 km at the apogee, 202 km at the perigee, 48°43′ inclination of the orbit to the equator, and 102-min period of revolution around the Earth.

Equipment

The 4-channel radio-spectograph used for this experiment, is swept over a frequency range of 0.6 to 6.0 MHz with a repetition period of 12 sec and a frequency resolution of 30 kHz. The radiospectrograph aerial, a crossed electric dipole system of 15 m length, perpendicular to the satellite axis of symmetry (Fig. 1) enables omnidirectional reception, necessary to avoid signal modulation caused by the rotation of the non-stabilized satellite. The sensitivity of the aerial immersed in the ionospheric plasma can be evaluated for each moment from the electron density and the ion-sheath diameter for the ambient plasma, which are continuously measured during the flight with the aid of the Soviet instruments, the low- and high-frequency impedance probes. Tape-recorded data of global coverage and resolution of 12

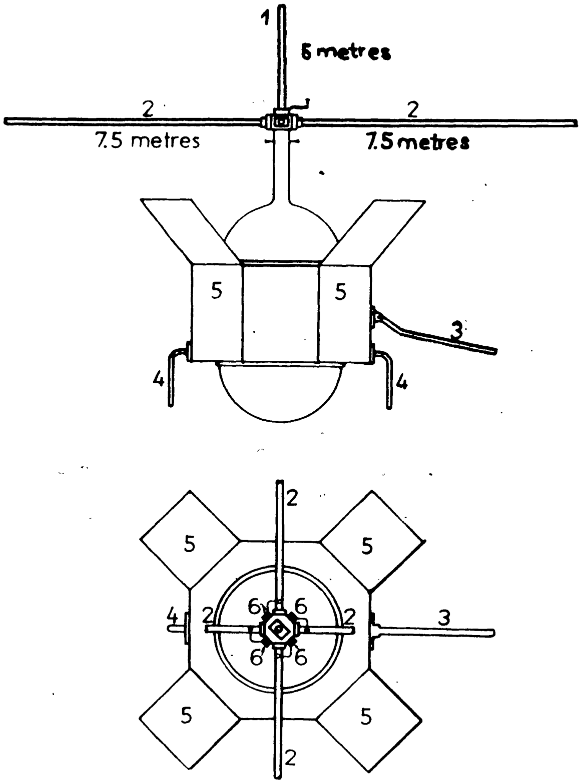

Fig. 1.

readouts per second for each channel were available for 7 to 8 hours daily. For rapid transmission of the radio-spectrograph operational data to the ground station at the Ondřejov Astronomical Observatory a special telemetry transmitter, developed in Czechoslovakia, was working aboard. The dynamic radio-spectrograph range was about 50 db, and noise and frequency were calibrated once per revolution.

Observations

A very limited fraction of the collected radio-astronomical data (for 4 observational days) has so far been made available for the analysis and, therefore, only preliminary results can be reported here.

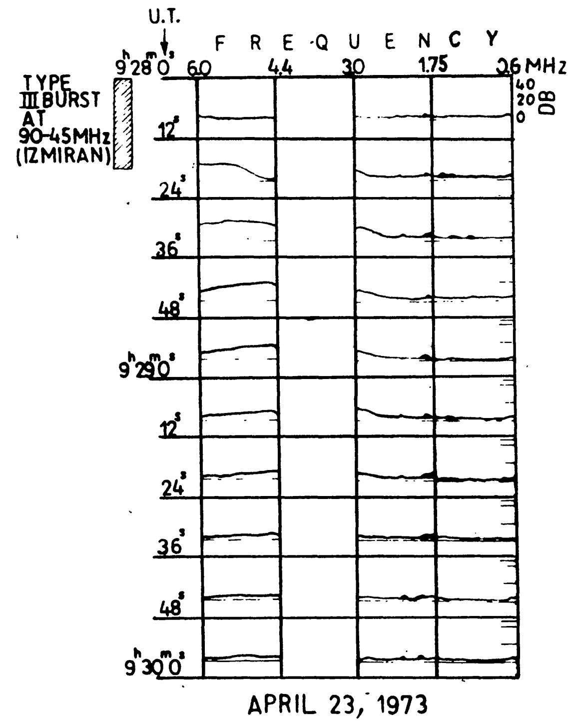

Fig. 2.

This sample of observations contains good examples of fast-drifting type III bursts. Some of the bursts, as recorded aboard, are shown in Figure 2 together with their ground based counterparts, as recorded at IZMIRAN near Moscow. These bursts are characterized by their drift from higher to lower frequencies and by the sudden rise and exponential decay, as can be seen from this figure. They last for more than 1 min in the frequency range of 4.4 to 6.0 MHz. The bursts, shown in the figure, were observed while the satellite was deep in the ionosphere, and the ionospheric cut-off frequency limited the useful data to the frequency range between 3 and 6 MHz. These bursts are commonly believed to be excited by fast electrons that travel along open field lines out through the corona into interplanetary space.

Determination of the Coronal Temperature

The exponential decay in type III bursts appears as a result of the damping of plasma waves, which seems to be due to Coulomb collisions between free electrons and ions (at least at higher frequencies). The decay constant τ depends on the electron temperature in the corona and on the local plasma frequency f_p according to the formula [1]:

$$t[^\circ\mathrm{K}] = 0.65 \times 10^{-4} f_p^{4/3} \tau^{2/3}, \qquad (1)$$

where τ is determined as the time the burst decays by the factor of 1/e. (It should be noted that this formula should be only applied for the exponential phase of the decay.)

The temperatures have been determined for the set of frequencies within the observed frequency range of 4.4 to 6.0 MHz. Using an electron density model for the outer corona, one is, therefore, able to obtain a temperature distribution over distance

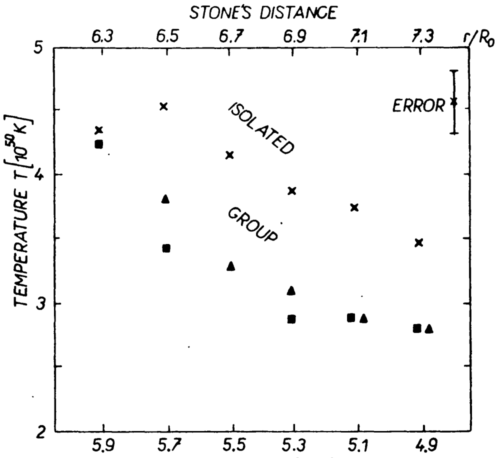

Fig. 3.

corresponding to the plasma levels in the limits of the observed frequency range. For the present study the electron density model, obtained by

Stone [4], has been adopted. The obtained temperature distribution have been shown in Figure 3 for 3 selected bursts (shown in Fig. 2), of which one (crosses) is isolated, and the two other (triangles and squares) have appeared in a group.

It can be seen from this diagram that at distances of about 6 to 7 solar radii the determined temperatures are 2.8 to 4.5×10^5 K, decreasing with the distance from the Sun. It has to be noted that for bursts separated by a period of about 2 hours we obtained a difference in temperature of about 60 to 70×10^3 K, whereas for both the bursts within the group the same temperature have been observed. A lower temperature was observed for the group of bursts that appeared earlier.

Discussion

According to Papagiannis [6], the coefficient (0.65) used in the Eq. (1) depends on the coronal temperature and electron density and, therefore, considering a coronal region of 6 to 7 solar radii, this coefficient should be equal to 1, and the results, presented here, should be multiplied by a factor of about 1.5. Nevertheless, our temperature determinations are in accordance with other estimates [2, 3]. Another question is, whether Eq. (1) resulting from the assumption of mere collisional damping, is at all applicable for temperature estimations in the upper layers of the corona. According to Zaitsev et al. [7] and Harvey et al. [5] Landau damping may play an important role in the coronal plasma.

Whilst the absolute values of the temperature determinations made here may look questionable, the relative difference of 70,000 K in the temperatures, observed between the isolated burst and the group, seems to be the real effect. However, we are not able to distinguish, whether the temperature difference comes from the increase of the local temperature in the same region of the corona during the period of 2 hours, or, the exciters of the isolated burst and those of the group travelled in the two separate regions of different local temperatures.

Acknowledgement

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References

1. AUBIER, M. and BOISCHOT, A. (1972): Astron. Astrophys., *19*, 343.
2. DUNCKEL, N. et al. (1972): Solar Phys., *25*, 197.
3. ELGARØY, Ø. and LYNGSTAD, E. (1972): Astron. Astrophys., *16*, 1.
4. FAINBERG, J. and STONE, R. G. (1970): X-639-70-389 Preprint GSFC (Goddard Space Flight Center).
5. HARVEY, C. C. and AUBIER, M. (1973): Astron. Astrophys., *22*, 1.
6. PAPAGIANNIS, M. D. (1971): In: C. J. Macris (Ed.), Physics of the Solar Corona, p. 315.
7. ZAITSEV, V. V., MITYAKOV, N. A., and RAPOPORT, V. O. (1972): Solar Phys., *24*, 444.