THE DAYTIME LOWER IONOSPHERE DURING THE SOLAR PHENOMENA OF JULY 27 TO AUGUST 16, 1972

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During the period of increased solar activity from July 27 to August 16, 1972, which also includes the proton flares of August 4 and 7, the absorption in the lower ionosphere was measured by the A3 method at a frequency of 0.06 MHz/ 850 km (Caltanizetta — Sofia). Phase-height measurements at 182 kHz/850 km (Ankara — Sofia), measurements of the field strength at 164/kHz) 1720 km (Allouis — Sofia) and measurements of the atmospherics at a frequency of 27 kHz were carried out at the same time. All measurements are carried out in the ionospheric observatory of Sofia (42.6°N; 23.4°E). The records of the proton flare of August 4 are shown in Figure 1.

On the basis of the above measurements it is shown that the absorption in the D-region is not only a qualitative indicator for the helio-physical processes, but also an instrument for quantitative evaluation of the solar ionizing radiation.

Energy Spectrum of the X-radiation During the Proton Flares of August 4 and 7, 1972 Obtained from Ionospheric Data

A method of aeronomical analysis of the D-region with a representation of the vertical distribution of the electron concentration by means of the exponential law (Nestorov, 1970a—c) is applied here. An important moment in the analysis is also the introduction of the investigations of the form of the energy spectrum distribution at $\lambda = 2 - 8$ Å under quiet conditions and increased solar activity (Nestorov, 1970a) and under strongly disturbed conditions (Apostolov, 1973).*

The electron concentration profiles prior to the beginning and in the maximum of the proton flares of August 4 and 7 are presented in Figure 2. On applying the equation of electron production of X-radiation at a given height, we obtained the spectrum of the ionizing X-radiation at the atmospheric boundary. In Figure 3 we present the integral flux of ionizing X-radiation at the atmospheric boundary, also prior to the beginning and in the flare maximum. The numerical values for the integral flux of X-radiation with $\lambda \leqq 3$ Å and $\lambda \leqq 8$ Å, obtained from ionospheric data for the proton flares of August 4 and 7, are comparable with the measurements of Solrad 10 (see Table 1).

After-effects of Proton Flares

In Figure 4 the average daily variation of E_{164} of the Allouis transmitter is given by a thick line. The monthly median is shown by a point and dash. In the upper part of Figure 4 the geomagnetic index A_p is given by means of dashes. It can be observed that while the daily field strength is near the median value up to August 7—8, 1972, from August 8 on the field strength E_{164} greatly increases to three definite maxima on August 9, 12, and 14. It is clear that these are after-effects of the proton flares of August 4 and 7 and of the greatly disturbed geomagnetic field during this period. For a better illustration of the first maximum the daily hourly variation of the field strength is given by a thick line in Figure 5. The hourly variation of the monthly medians is given by a dashed line. The great increase of E_{164} can be seen clearly after 10.00 UT on August 8, which also continues on August 9. On August 10 the field is normal.

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* A full statement of the analysis illustrated with the processing of different SID-effects is given by Nestorov, G. (1972): Geomagn. Aeron., XII, No. 1, 44.

Table 1

Time	By ionospheric data		Solrad 10	
	F ($\lambda \leqq 3$ Å)	F($\lambda \leqq 8$ Å)	F ($\lambda \leqq 3$ Å) erg cm^{-2} sec^{-1}	F ($\lambda \leqq 8$ Å)
Aug. 4 06.00 UT (begin. of SID)	1.12×10^{-5}	5.68×10^{-4}		6×10^{-4}
06.38 UT (max. of SID)	9.20×10^{-2}	8.87×10^{-1}	$\geqslant 7.46 \times 10^{-2}$	$>4.56 \times 10^{-1}$
Aug. 7 15.00 UT (begin. of SID)	7.03×10^{-5}	4.80×10^{-3}		5×10^{-3}
15.22 UT (max. of SID)	1.40×10^{-1}	6.36×10^{-1}	$\geqslant 8.95 \times 10^{-2}$	$\geqslant 4.95 \times 10^{-1}$

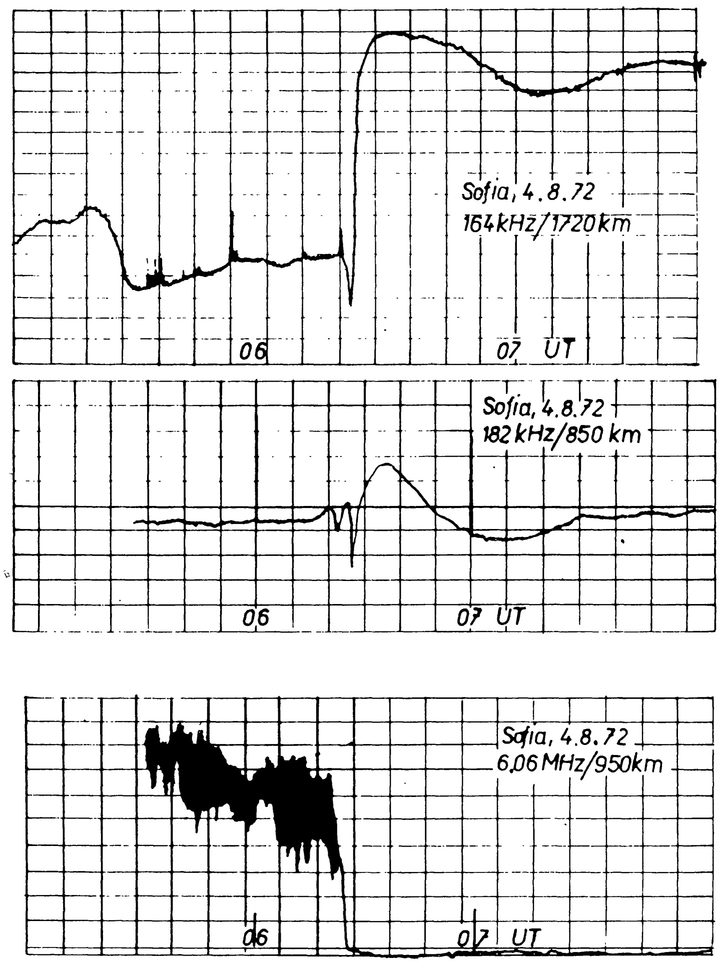

Fig. 1. Records of the proton flares of August 4, 1972.

The X-radiation under 8 Å is the main ionization source in the lower ionosphere at high solar activity and at mean solar activity its ionization effect is realized with that of L_α (Nestorov and Apostolov, 1972). In the lower part of Figure 5 the $F_{1-8\,Å}$ hourly variation for the period 7—10 August is

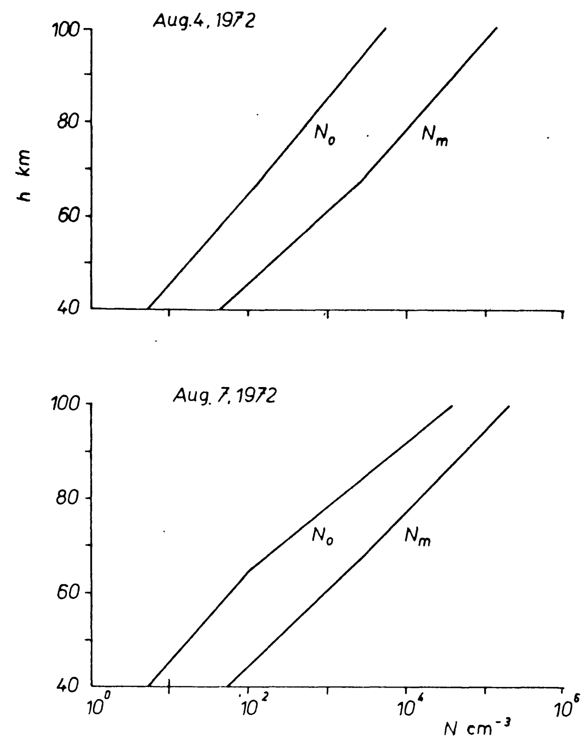

Fig. 2. Electron concentration profiles prior to the beginning (N_0) and in the maximum (N_m) of the proton flares of August 4 and 7, 1972.

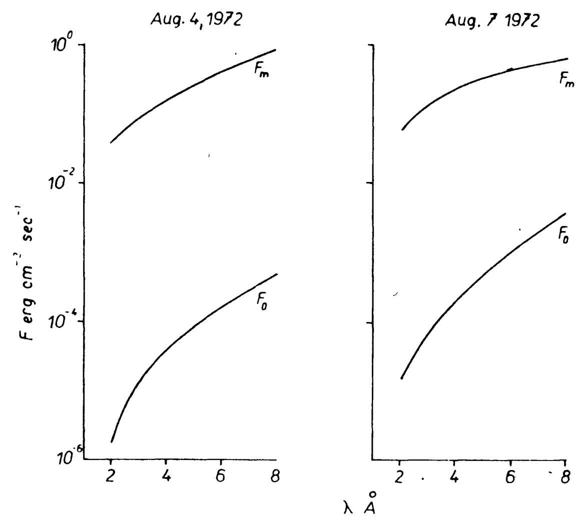

Fig. 3. Integral flux of X-radiation at the atmospheric boundary prior to the beginning (F_0) and in the maximum (F_m) of the proton flares of August 4 and 7, 1972.

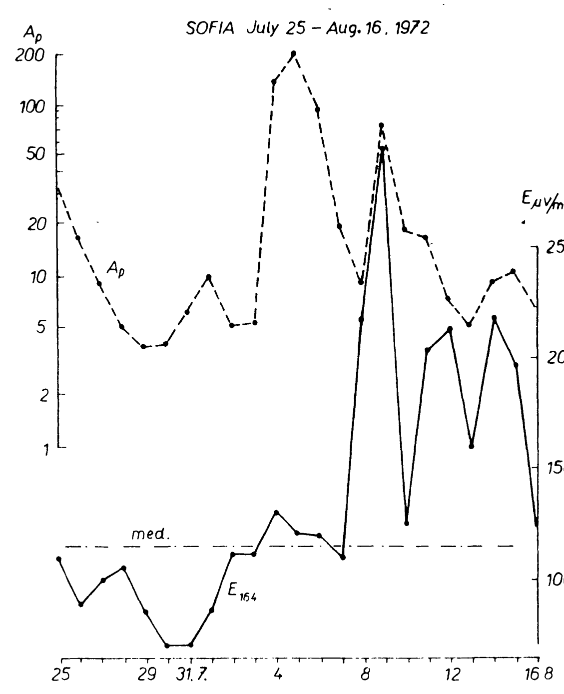

Fig. 4. Average daily variation of the field strength of 164 kHz/1720 km (E_{164}) (thick line) and the monthly median (point and dash). By means of dashes the geomagnetic index A_p is given.

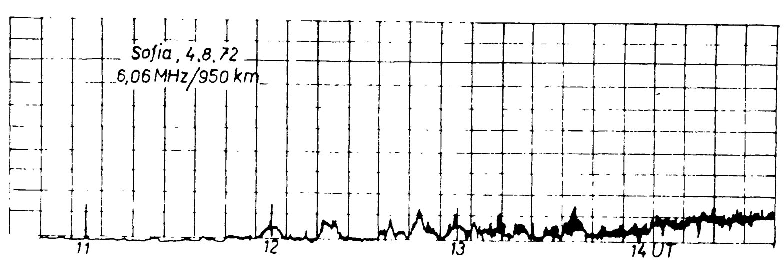

Fig. 6. Record of the field strength of 6.06 MHz/850 km of August 4, 1972 in the concluding period of SID.

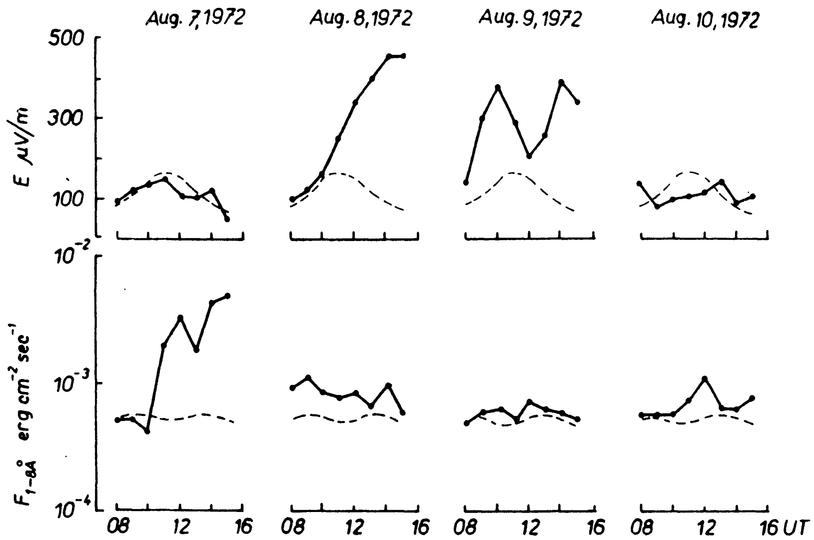

Fig. 5. Hourly variation of the monthly medians (dashed line) of E_{164} and $F_{1-8\,Å}$ and diurnal hourly variation (thick line) of E_{164} and $F_{1-8\,Å}$ for the period August 7—10, 1972.

presented with a thick line, and the hourly variation of the monthly medians is represented with a dashed line. From the comparison of the hourly variation of the field E_{164} and the hourly variation of the X-radiation flux $F_{1-8\,Å}$ it is seen that the after-effects of the proton flare of August 7 are not due to changes in the X-radiation flux.

Similar diagrams may be made for the remaining two maxima as well.

Such after-effects along the investigated path are also observed in other cases of powerful solar flares (Nestorov, 1971).

The most probable mechanism of these effects is a weakening of the CR-layer as a consequence of the shading of the cosmic radiation by an abundance of energy particle floods around the earth during the studied period (modulation processes). Another reason for the increase of E_{164} may be the increase of the gradient of electron concentration in the reflection region as a consequence of the additional ionizing source.

The Contribution of X-radiation 1—8 Å in the Ionization of the D-region

The increase in the X-radiation on August 4 and its slow decrease after the flare is a good basis for investigating its influence on the ionization of the D-region. As shown in Figure 6, where a given part of the record of the field strength of 6.06 MHz for August 4 is shown in the concluding period of an SID, the field strength begins to recover after 13.00 UT while at 14.00 UT the absorption is still quite large compared to the pre-flare period. According to the data in Solar Geophysical Data, 1973, the $F_{1-8\,Å}$ flux before the proton flare is about 1×10^{-3} erg cm^{-2} sec^{-1}. At 14.00 UT $F_{1-8\,Å} \approx 6 \times 10^{-3}$ erg cm^{-2} sec^{-1} and, as seen in the record, this flux is the reason for the considerable absorption in the D-region. This is where the essential influence of X-radiation on the ionization of the lower ionosphere can be seen.

References

APOSTOLOV, E. M. (1974): Bull. Astron. Inst. Czech., *25*, 268.

NESTOROV, G. T. (1970a): Compt. rend. Acad. Bulg. Sci., *23*, No. 8, 939.

NESTOROV, G. T. (1970b): Compt. rend. Acad. Bulg. Sci., *23*, No. 9, 1079.

NESTOROV, G. T. (1970c): Compt. rend. Acad. Bulg. Sci., *23*, No. 10, 1207.

NESTOROV, G. T. (1971: Compt. rend. Acad. Bulg. Sci., *24*, No. 10, 1317.

NESTOROV, G. T. and APOSTOLOV, E. M. (1972a): Compt. rend. Acad. Bulg. Sci., *25*, No. 10, 1343.

NESTOROV, G. T. and APOSTOLOV, E. M. (1972b): Solar-Geophysical Data (ESSA — Bould.) No. 388 — Part I.

NESTOROV, G. T. and APOSTOLOV, E. M. (1973): Solar-Geophysical Data (ESSA — Bould.) No. 342 — Part II.