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FLUX OF SOLAR XUV RADIATION INFERRED FROM IONOSPHERIC VARIATIONS DURING THE ECLIPSE OF 20th, MAY 1966

INTRODUCTION

The primary photon interactions and associated effects of Solar X-rays and ultraviolet (UV) radiation are of greatest importance to the structure of the Earth's atmosphere above 100 km. This part of the upper atmosphere which is mostly under control of incident Solar XUV (λ = 30 - 1750 Å). is commonly called Ionosphere.

First of all, it is important to emphasize the fact that only little direct experimental data of absolute flux of incident Solax XUV radiation has been accumulated over the period of the Quiet Sun (1963 - 1966). Data from satellite experiments are available only for certain wavelength bands. There are only several satellite data of incident Solar flux.

$$\lambda = 170 - 1027 \text{ Å}$$

which is of dominant importance for ion production in the atmosphere above 100 km under quiet conditions. That is why estimation of Solar XUV flux (λ = 170 - 1027 Å) from ionospheric measurements during Solar eclipse of 20^{th} May, 1966 contributed to fill up deficiency in knowledge about this part of Solar spectrum.

The Solar Eclipse variation of ionospheric characteristics

The central line of Solar eclipse of 20 May, 1966 crossed Yugoslavia near midday; beginning at $09^h 10'00''$ maximum at $10^h 37^m 03^s$ ant the end was at $12^h 03^m 08^s$ of local time. At the altitude of the E - layer, the maximum optical accultation of the Sun's disk was about 79% over Belgrade (44° 48' N; 20° 31' E; mag dip 61°). All measurements during the eclipse were taken by automatic ionospheric recorder in the Institut "Mihailo Pupin".*) During the eclipse 122 ionograms have been taken, and during control days of 18^{th} and 19^{th} May, 307 ionograms have been taken under the same conditions. Control days and eclipse day were magnetically quiet ($K_p = 1$). Analyzing the ionograms the typical Solar eclipse variations of critical frequencies: f_oE, f_oF_1 and f_oF_2 were found (Fig 1 and Fig 2). Solar eclipse phenomena in ionosphere were used by other authors (1, 2, 3) for calculation the value of effective recombination coefficient (α_{eff}). All of them have got the values (10^{-8} cm^3 sec^{-1} < α_{eff} < 10^{-7} cm^3 sec^{-1}) which are, by several order of magnitude, greater than should be expected according to the theory (4).

In this paper α_{eff} was calculated from eclipse phenomena over Belgrade, and the flux of Solar XUV Radiation at the boundery of Earth's atmosphere (I_∞).

Interpretation of Results

It is well known (5) that maximum electron density of E-layer could be found from:

$$N_{max} = 1,24 \times 10^4 \; (f_oE)^2 \qquad (1)$$

*) Programme was carried under the financial support of the Federal Council of Scientific Research.

Electron density is function of time and can be evaluated by numerical integration of the continuity equation:

$$\frac{dN}{dt} = q\,(h,\ t) - \alpha_{eff}\, N^2\,(h,\ t) \qquad (2)$$

α_{eff} - effective recombination coefficient

q(h,t) - ion production rate, which on certain height is given by (5):

$$q\,(t) = \frac{\sigma_{\lambda} \cdot n \cdot I\,(t) \cos \chi}{\varepsilon_{\lambda}} \qquad (3)$$

σ_{λ} - the absorption cross section

n - mean number density of O_2 and N_2

χ - Solar zenith angle ($0,76 < \cos \chi < 0,89$ during eclipse)

ε_{λ} - efficiency of radiation

I (h) - Solar flux at the certain level (h) given by:

$$I\,(h) = I_{\infty} \cdot e^{-\mu_{\lambda}\, \rho\, H \sec \chi} \qquad (4)$$

μ_{λ} - mass absorption coefficient

ρ - density of neutral atmosphere = $\rho_o\, e^{-h/H}$

H - $\frac{RT}{mg}$ scale height

I_{∞} - incident Solar flux at the boundary of Earth´s atmosphere

Supposing, that there is no significant change of α_{eff}, (and other parameters) with height during the eclipse, we were able to solve (3) and (4) as the function of time, and to find I(h) ant I_{∞} at the maximum phase of the eclipse. This assumption could be held because of quasi stationary conditions near midday when eclipse took place. Under such circumstances α_{eff} was calculated from equation (2) Fig 2 for E-layer in the maximum of the eclipse:

$$\alpha_{eff} = \frac{q\,(t)}{N^2(t)} \qquad (5)$$

Values for the electron density N(t), and ion production q(t) were taken from our measurements. The value for effective recombination coefficient obtained by such way is:

$$\alpha_{eff} = 2 \times 10^{-7}\ cm^3\ sec^{-1}$$

Values for H, ρ, μ_{λ}, σ_{λ}, ε_{λ} and n are taken from CIRA model (6) for wavelengths $170 < \lambda < 1027$ Å, and for height of 100 km.

Using all the above mentioned parameters the incident Solar flux ($170 < \lambda < 1027$ Å) has been calculated and its results are as follows:

$$I(h)_{\text{control days}} = 5,0 \times 10^{10} \text{ photons cm}^{-2} \text{ sec}^{-1}$$

$$I(h)_{\text{max eclipse}} = 3,1 \times 10^{10} \text{ photons cm}^{-2} \text{ sec}^{-1}$$

$$I_{\infty} = 5,0 \times 10^{10} \text{ photons cm}^{-2} \text{ sec}^{-1}$$

Rocket experimental data are (7):

$$I_{\infty\, 170 < \lambda < 205 \text{ Å}} = 7,0 \times 10^{9} \text{ photons cm}^{-2} \text{ sec}^{-1}$$

$$I_{\infty\, 911 < \lambda < 1027 \text{ Å}} = 3,5 \times 10^{11} \text{ photons cm}^{-2} \text{ sec}^{-1}$$

Conclusion

In this paper the incident Solar flux was estimated by measuring electron density and ion production in ionosphere during Solar eclipse of 20th May, 1966 over Belgrade. The obtain results are compatible with the rocket data which is the proof for calculated α_{eff} value.

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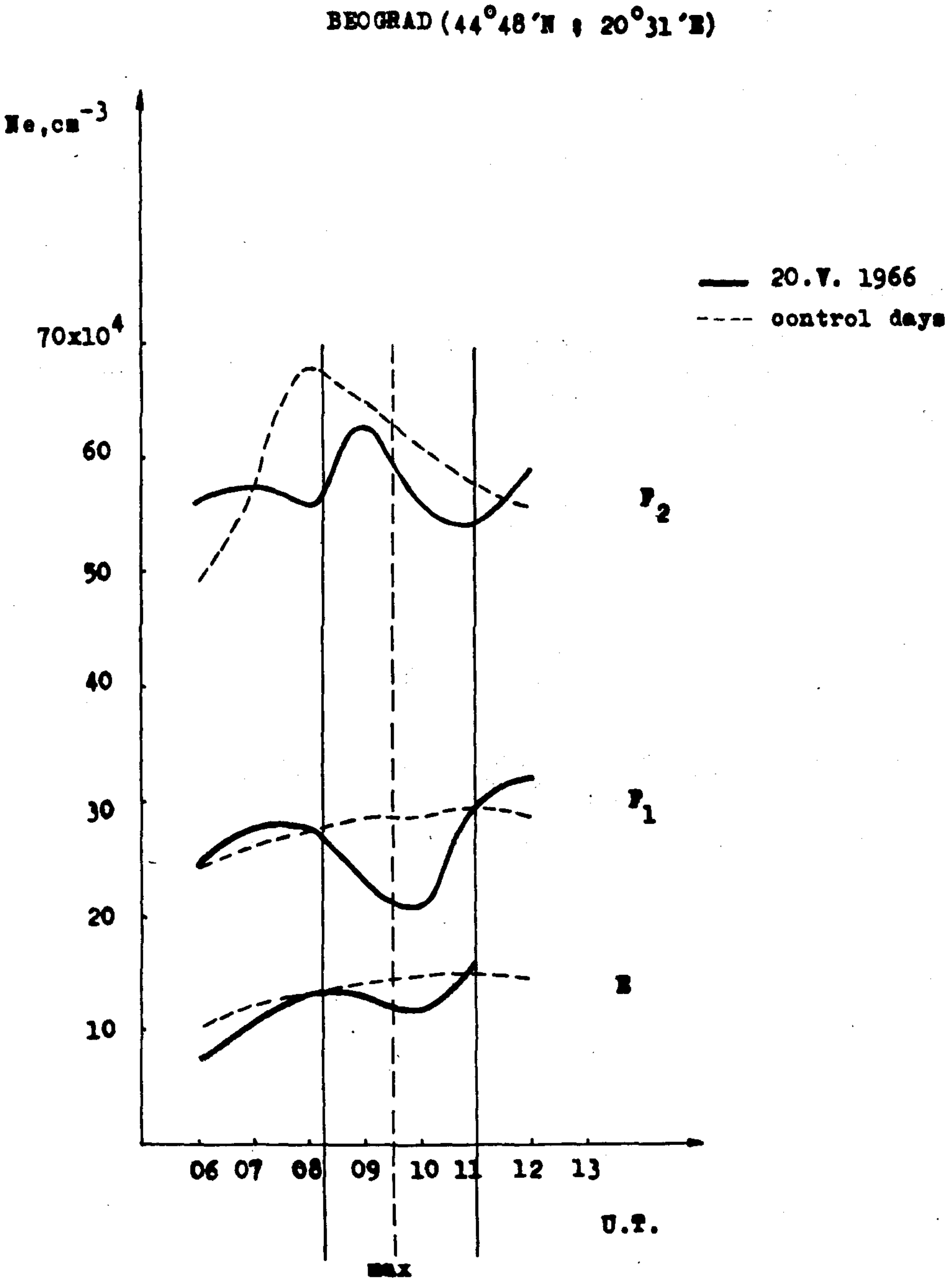

Fig 1

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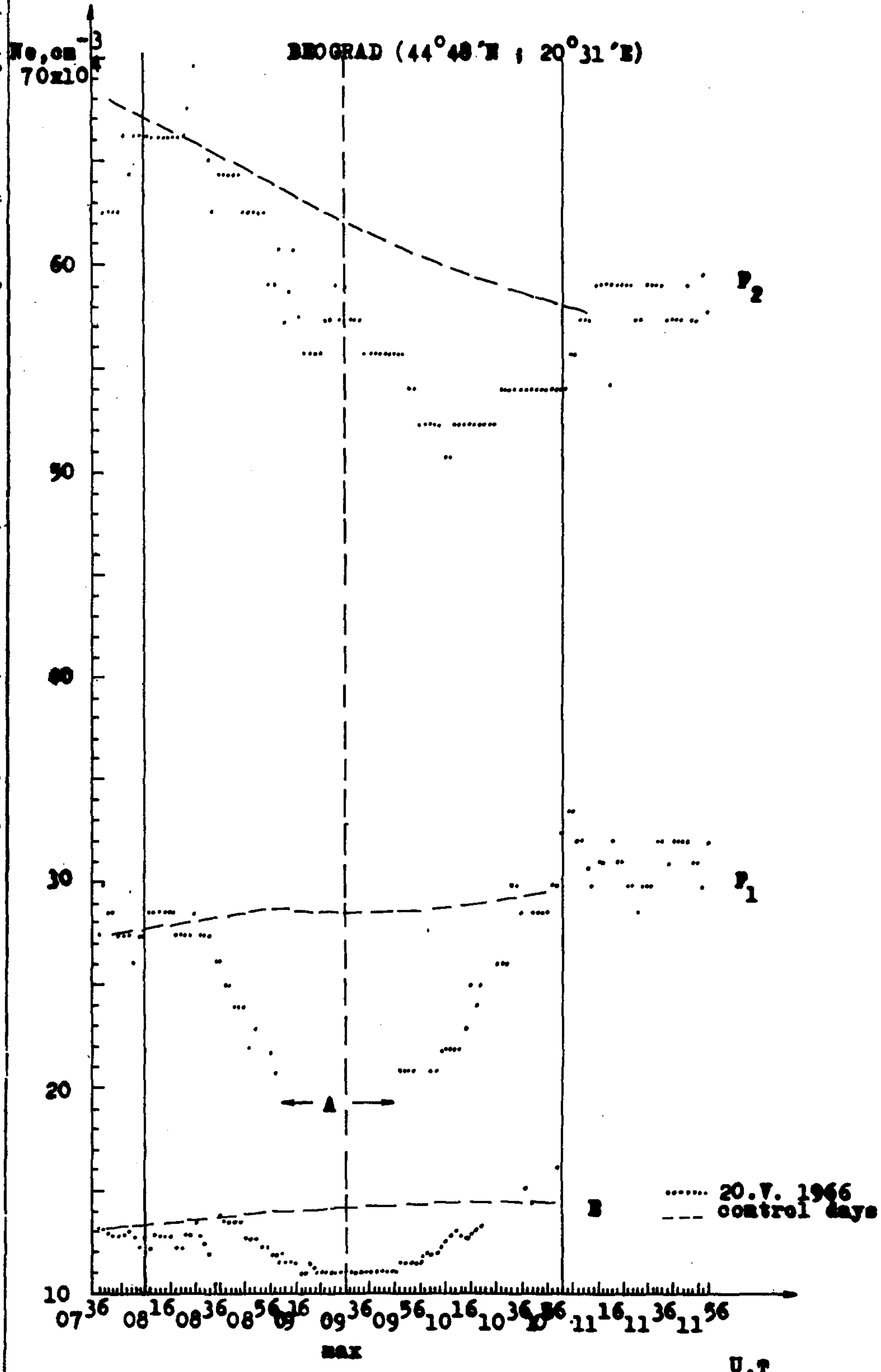

Fig 2