INVESTIGATION OF THE ONBOARD INSTRUMENTS PHOTOCURRENT DURING SOLAR MAXIMUM

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***Abstract*—The photocurrent characteristics emitted by the onboard space plasma instruments of the satellite "Intercosmos Bulgaria - 1300" was investigated. In existing data base was made the massive search for the interesting registered events during the full satellite live. The precision solar spectrums data from the present solar minimum are applied on the possible photocurrent zones for the different materials used in the space instrumentation. Spatial attention was given to the 21 cycle of the solar maximum. All interesting orbits are discovered close to the peak of the solar activity of this cycle. The data processing results was shown in the chart.**

1. Introduction

THE satellite "Intercosmos Bulgaria-1300" (ICB-1300) was launched in 13:35h on 7 august 1981 at almost polar orbit with initial parameters - perigee 826 km, apogee 904 km and inclination 81.2° from launching platform №43/3 from Plesetsk cosmodrome with the Vostok-2M carrier. It is known also as "Intercosmos 22" with catalog number 1981-075A. The spacecraft was three-axis stabilized, based on the Meteor bus, with the negative Z-axis pointing toward the center of the earth and the X-axis pointing along the velocity vector with accuracy of the ±1°. The weight was 1500kg and electrical power of the solar battery was 2kW. The scientific payload consists from 12 instruments - 11 for space plasma, electric and magnetic fields investigations, aeronomic studies and one for geodesycal purposes. All satellite surfaces were electrically conductive including solar panels. This technical data will be used later in the analysis of the photoeffect from the surface of the cylindrical Langmuir probe, worked onboard ICB-1300. The lunching and main measurement made by ICB-1300 was done on the period of the 21 sun cycle. Information about sun cycles can be found in [1]- [3]. Different graphical charts for the 21 solar cycle can be found [4]-[6]. As it can be seen from Fig.1 the time duration of the 21 solar cycle is from 1976 to 1986 and maximum of the solar activity is from September 1978 to April 1982. For this period the sunspot number is between 130 and 190. The absolute maximum is in the beginning of the September 1979 with the 190 sunspots. On the Fig.1 the red line is the monthly smoothed sunspot number [5] and the blue line is the actual monthly sunspot number by the data from [6]. The observations of the total solar irradiance (TSI) for the 21 cycle from space based instruments are in the beginning. As it can be seen in [7] there are two working instruments aimed to investigate TSI during 1980-1985 – NIMBUS7/ERB and SMM/ACRIM1. In [7]-[9] is shown that the scientific instruments have the differences in measurements and cannot be lead a correct comparison between TSI spectrums from different solar cycles. This fact is directly connected with active life period of the "ICB-1300". From [9] can be evaluated that differences between these instruments in measured value of the TSI is within 5-6 W/m^2. That is one of the reasons to process the amplitudes of the sun spectrums for closer time period, but the main one is the absents of continuos data for the daily solar spectrum in the wide range including diapason below 300nm and 100 nm for 21 solar cycle maximum. There is data available from different sources

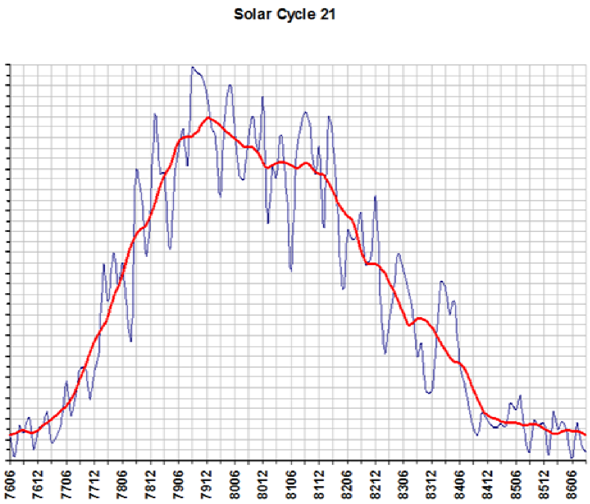

Fig.1.The 21 solar cycle with maximum September 1979 [5].

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for TSI in this period with gaps in the ranges of the wavelength. Unfortunately for our calculation it is unusable.

2. Analysis

Let assume that the monochromatic energetic flux on the body is E_ν, in the body potential of $\varphi_0 = 0$. The flux of the photoelectrons N_ϕ from the unit of surface in one unit of time can be estimated by the correlation (1).

$$N_\phi = \int_0^\infty \frac{E_\nu}{h\nu} k_\nu d\nu \qquad (1)$$

There k_ν is quantum yield of the body material for the radiant flux with frequency ν and h is the Planck's constant. The full photocurrent from the surface of the spherical body with radius R_0 (we do not account of the effect of the angle of the flux) on the quantum effectiveness will be (2):

$$I_\Phi = \pi R_0^2 N_\Phi e \qquad (2)$$

There e is the electron charge.

It is necessary to mean, that with growing of the positive body potential, near to it is formed the shielding layer of a negative volumetric charge, which causes reducing of the photocurrent.

2. Numerical calculations

The calculations will be made based on the data for the TSI available from the [10], [11] for the daily sun spectrum for the present year. On the Fig.2. [6] is shown the 23 solar cycle. On January 4, 2008 appeared a reversed-polarity sunspot—the signals for the start of solar cycle 24. The September of 2008 is close to the absolute zero of sunspot numbers and concrete for the 1-st September 2008 it is zero [12].

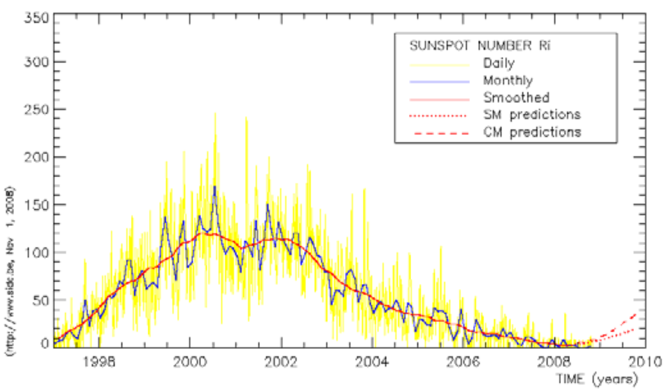

Fig.2. The 23 solar cycle sunspot number profile.

Based on this it become possible to make some numerical analysis for the difference between suns maximum in 21 cycle and present absolute minimum. For this it can be made the integration of the sun spectrum energy for the concrete day. On the Fig.3 is shown the data and the interpolation curve for the 1-st September 2008.

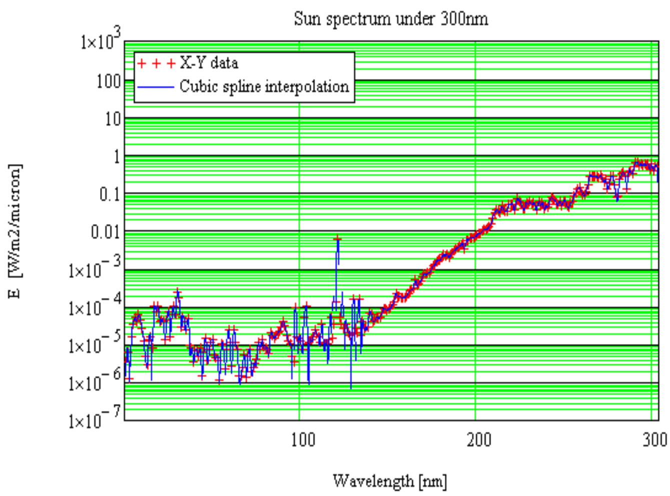

Fig.3 Cubic spline interpolation 01.09.2008 spectrum.

The red markers are the data and the blue line is the cubic spline interpolation. From this is easy to make the integration. On the Fig.4 is shown the profile of the received value of the integrated sun spectrum. The energy levels below 130nm are low.

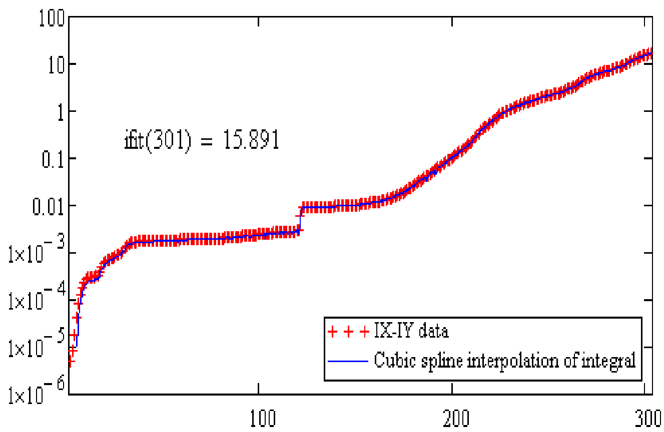

Fig.3. Curve of the spectrum integration for 01.09.2008.

The integration diapason is chosen there by the physical reasons – above 300 nm the photoeffect is impossible.

3. DISCUSSION

It is not difficult to calculate the diapason of the frequencies, where photoeffect take place. For the aluminum (Al) the beginning is in wavelength λ=290nm, for the tungsten (W) λ=275nm and for the gold (Au) λ=230nm.All this value can be seen on the Fig.5. They are placed on the plotted sun spectrum for the 17 May 2008. In this day [12].the sun spot numbers is 12. Additional information for the on the photoemissions and work function for the different materials and is discussed in [14], [15].

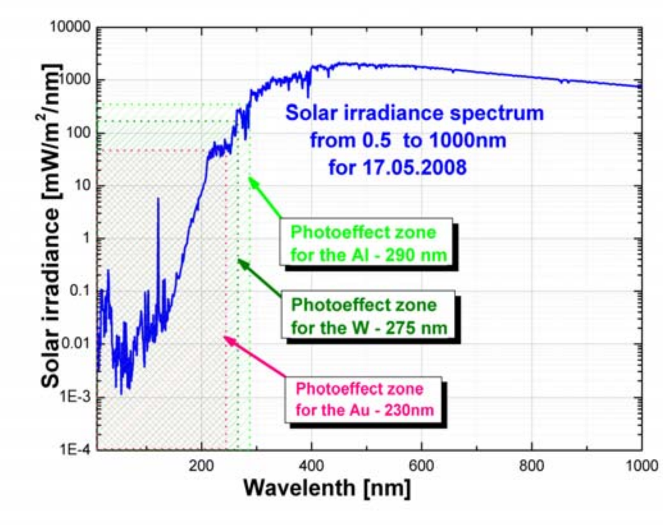

Fig.4. Comparison of the zones of the photoeffect for different materials on the solar spectrum for the 17.05.2008.

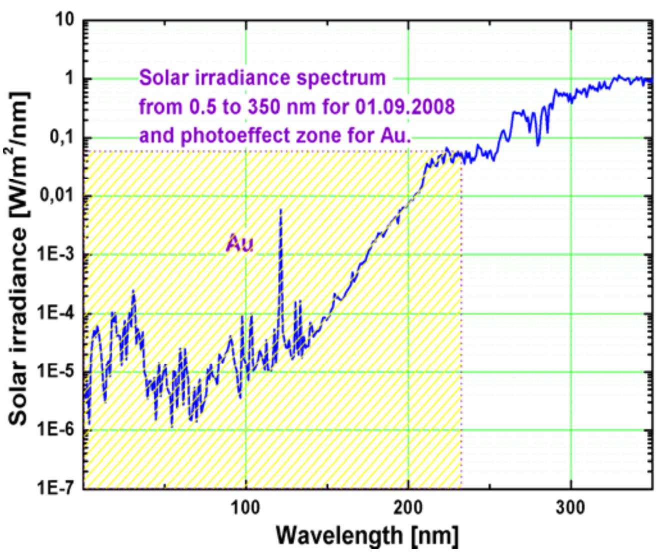

Fig.5. Extended photoeffect zone for the Au on the solar spectrum for 01.09.2008 in range of 0.5nm to 350nm.

The gold Au is one of the often used for the plating. In our case the surface of the cylindrical Langmuir probe worked onboard ICB-1300 was with golden surface. The range of the photoeffect zone disposed on the sun spectrum data for the 1-st September 2008 is sown on the Fig.5. As it can be seen the energy levels starts from 0.1 $W/m^2/nm$.

3. EXPERIMENTAL RESULTS

The analysis of the numerical missives searching events of the shadowing CLP sows a few results. The shadowing can be classified mainly by two cases. The first one is the shadowing by the satellite body and the second one is the shadowing by the power panels. The analysis of the digital missives lead to the following results approximately equal data - an average reduction n_e is in order:

Panel shadowing - $\Delta n_e \cong 3.5.\,10^3\ cm^{-3}$ (1)

Terminator effect - $\Delta n_e \cong 7.10^3\ cm^{-3}$ (2)

The calculated amplitude of the collector's current is possible to estimate by formula:

$$i_u \cong a.n.e.v_0.S \qquad (3)$$

Where:

α - transparency coefficient of the sensor,

n - density in cm^{-3}

e – electron charge

v_o - *a* spacecraft velocity in cm/s

S - sensor effective surface charges collecting.

From (3) for the satellite surface photocurrent can be calculated:

$$i \cong 105.10^{10}e\ [cm^{-2}.s^{-1}] = 166.10^{-9}\ [A.cm^{-2}] \qquad (4)$$

The analysis of the found orbits with recognized phenomenon of the probe shadowing effect allows estimate directly the photocurrent emitted from the CLP surface. On the Fig.6. is shown the curves of the orbit 232. The potential difference between probe and satellite body was also direct measured by electrostatic field measurement instrument - IESP. In the moment of the crossing the terminator UT≈21.04h the electron density ne is jumping. To provide correct space plasma investigations it is necessary to have equipotential spacecraft body. This can be achieved by the additional covering of the solar panels with the conducting grid. By this the satellite body surface increase significantly. The proportion of the conducting surfaces between the satellite body and cylindrical Langmuir probe is more than 1000 times. Moreover on the lighted part of the orbit this proportion guarantees the negative potential of the CLP surface in reference to the spaceship. Must be mentioned, that the orbit 232 is on the 23 August 1981. From the Fig. 1 can be seen that this orbit is close by the sunspot numbers to the absolute maximum for the 21 solar cycle.

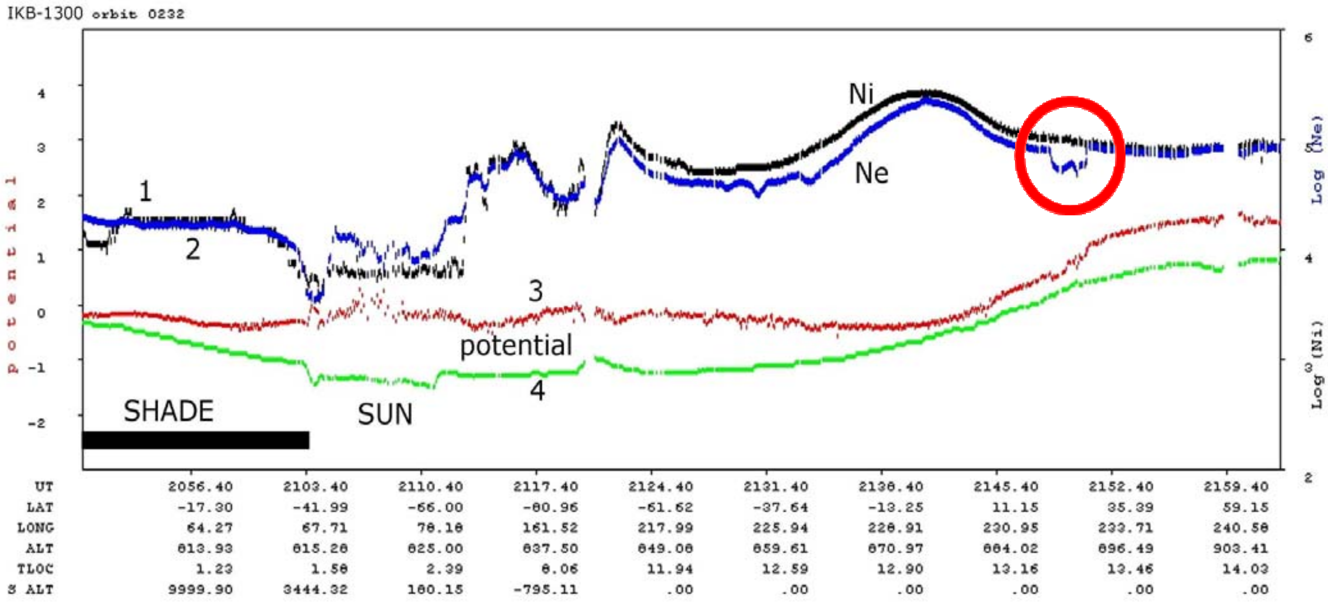

Fig.6 Electron and ion densities and satellite body potential measured onboard "Intercosmos Bulgaria -1300" and shadowing effect on CLP n_e measurements observed on the orbit 232.

With the red circle on the orbit is marked the shadowing of the CLP onboard ICB-1300by the power panels. The curves 3 and 4 below the red circle are not affected by the shadowing effect. This shows that the satellite potential is not affected seriously by the shadowing.

3. Conclussions

The measuring of the electron density n_e by the double asymmetrical probe (satellite body – spherical electric field probe) leads to the dependence of the parameters of the density n_e and satellite body potential, which can be seen from the analyzed results.

The photocurrent influence on the satellite potential is weak. This is clearly expressed by the behavior of the curve 3 on the Fig. 6.

The mathematical calculations show a good agreement with results received from other researchers.

The observed phenomenon of the photocurrent in the 21 cycle of the solar maximum allow to assume, that for a short time periods less than 5 minute the measured n_e can be changed with a $3.5 \div 4.10^3$ cm^{-3} .

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