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PHOTOCURRENT INVESTIGATION BY THE "ICB-1300" SATELLITE DATA

Stefan Chapkunov [1], Roumen Shkevov[1], Georgi Karamishev[2]

[1] Space Research Institute – Bulgarian Academy of Sciences
[2] Geophysical institute - Bulgarian Academy of Sciences
e-mail: schapkanov@space.bas.bg

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Abstract*: The results from the photocurrent investigation are summarized, mainly from the Langmuir probe surface, during work time on the satellite "Intercosmos Bulgaria -1300". There is used the data from the probe instruments worked on board spacecraft. The amplitude estimation of the registered photocurrent is made.*

Introduction

The solar irradiance spectrum is main topic interest area for many scientific investigators last years. There was developed a different programs and were build the instrument structures aimed to better understanding the observed sun's processes. The influence of the sun on the spacecraft functioning is one of the investigated areas. The spectrum of the emitted solar irradiance is directly connected with some secondary effects like photocurrent form the spacecraft surface. In particular this paper presenting some calculations to determine where exactly starts the photoeffect from the golden surface. Fig. 1 shows a real data plot of sun irradiance spectrum [1], [2] and the photoeffect zone – the green one. The information about "IKB-1300" experiments and used data can be found in [3], [4]. Ion density $\boldsymbol{n_i}$, calculated in the range 10^2 - 10^6 cm^{-3}, is received by the data from trielectrode ion trap with the floating potential outer electrode – curve 1 from Fig. 2. Electron density $\mathbf{n_e}$ is received by the cylindrical Langmuir probe (CLP) – curve 2 with the registration range of the 5.10^2 – 3.10^6 cm^{-3}. The CLP is mounted on the boom longer than 1.5 m. There also was used data from the electric field analyzer – four spherical sensors with the amorphous carbon surface, placed in the suitable points to measure the electric field vector components.

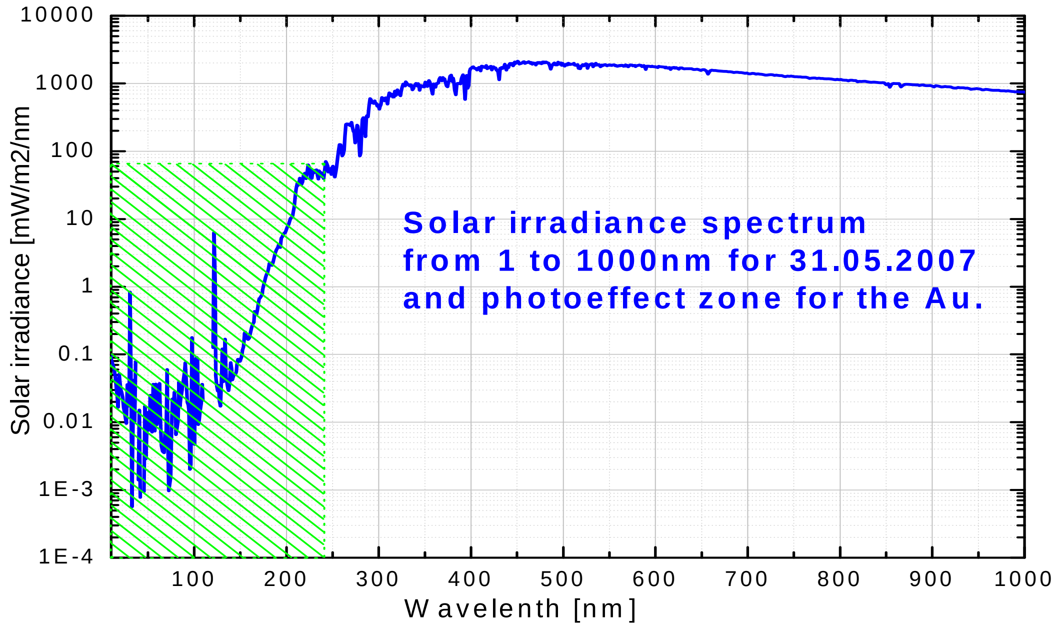

Fig.1. *Solar irradiance spectrum 1-1000nm and photoeffect zone for the Au.*

The electric field measurements sensors are made from the vitreous carbon and are mounted on the 4 meters long electrically conductive booms. The potential difference measured between one of the electric field sensor and satellite body – curve 4. In [5] is pointed that, the registration of this potential difference is depending by the electric field components **Ey** and **Ez** values and the correlation coefficient is 0.96. There is shown the value of the potential (curve 3) [4] of the plasma, calculated by the specific point from the curve of the I-V characteristics of the cylindrical Langmuir probe instrument. In the [6, 7] can be found many useful information for the calculation from the solar irradiance spectrum.

Experimental results

On the Fig. 2 and Fig. 3 is shown the curves of the discussed above parameters during orbit 232 and 386. The thick line in lower part on the Fig.2 corresponds to time, in which satellite was in shade of the Earth. The main aim of this investigation is to estimate the photocurrent influence on the satellite potential. 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 Fig. 2 UT≈21.04h the electron density $\mathbf{n_e}$ is jumping. The reason of the registered increasing of the $\mathbf{n_e}$ is the photoelectrons from the satellite surface exposed on the sun radiation which is the reason of the sharply increasing of the electron component of the plasma. Until this time, in the shadowed part of the orbit electron $\mathbf{n_e}$ and ion $\mathbf{n_i}$ densities nearly coincide. At the same time the satellite potential (curve 3) is negative corresponding to the grounded plasma. This can be explained with the fact that the plasma in this moment is quasineutral – the curves of the electron and ion densities coincide, because the speed of the electrons is higher in order than this of the ions. When the satellite goes on the sun begins the process of photoelectron emission as from the body that from the probe surface. 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. This is one of the main reasons to carry out the correct probe measurements. Moreover on the lighted part of the orbit this proportion guarantee the negative potential of the CLP surface in reference to the spaceship. This can be observed on the Fig. 2 curves 3 and 4.

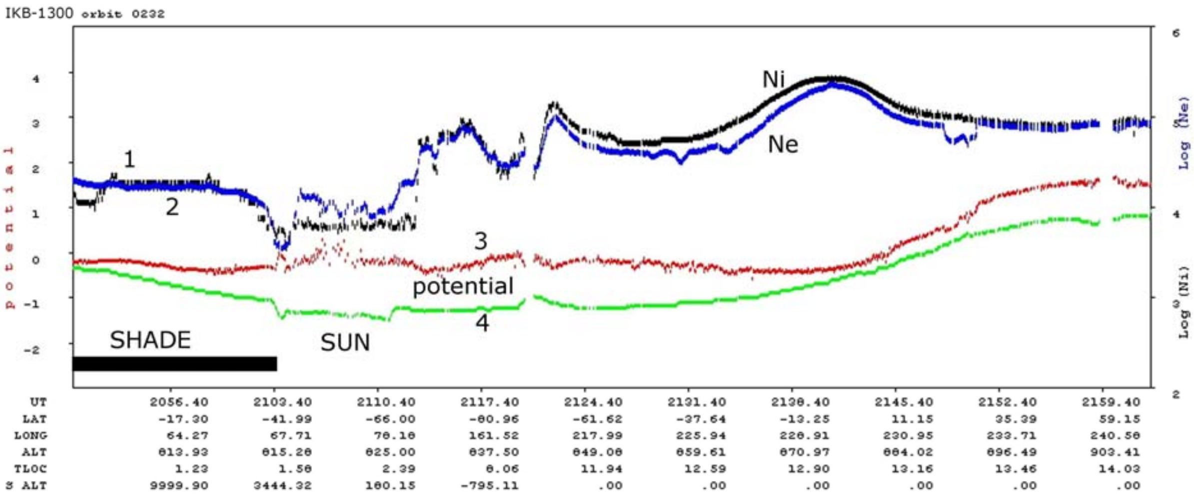

Fig. 2. *Electron and ion densities and satellite body potential measured onboard "Intercosmos Bulgaria1300".*

The analysis of the numerical massive in both events of the shadowing CLP shows approximately equal data - an average reduction n_e is in order:

(1) Panel shadowing - $\mathbf{\Delta n_e} \cong 3.10^3$ cm^{-3}

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

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

(2) $i_u \cong \alpha . n . e . v_o . S$

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.

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

The collector current of the trielectrode ion trap (in the wide range of the satellite orbit the values of the electron n_e and ion n_i densities are approximately equal and it is convenient to be used formula (2). There is a similar situation at the orbit 232, where shadowing of the probe and the booms from the power panel in the UT≈21.09h can be clearly expressed. The amplitude of the photocurrent from the probe is close to the value from the expression (3). At the moment UT≈20.46h the probe and the boom is shadowing from the satellite body, the photocurrent is breaking (electron density is dropping) and the plasma potential is again dropping.

The comparison with theoretical result shows noticeable increasing of the photocurrent that probably is due to the experiments onboard “Intercosmos Bulgaria-1300” was leaded at period of the maximum solar activity.

On the Fig. 3 is shown the influence of the event - crossing the terminator and going to the sun - on the electron temperature Te. There can be observed “cold” electrons and this lead to some changes in the probe characteristics. The processing software give an interpretation like lower temperature, regardless in fact it is measured two type of electrons with a different energy. There must be mentioned that the Langmuir model, used to process the characteristics do not suppose the presence of electrons with a big difference in their energy spectrum, like is in this case.

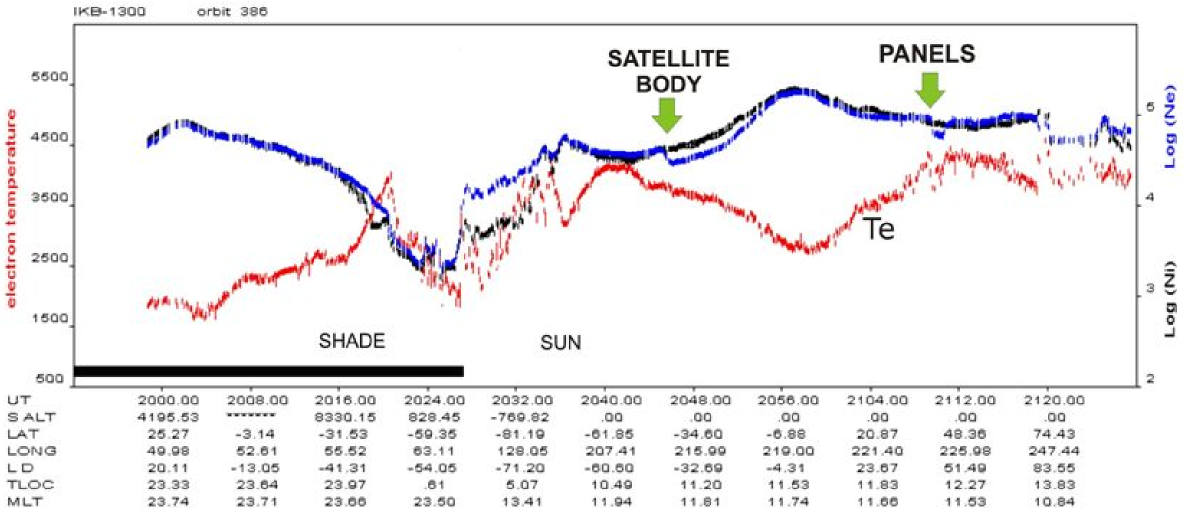

Fig. 3. *Probe shadowing effect observed onboard “Intercosmos Bulgaria 1300”.*

Conclusion

The measuring of the electron density $\mathbf{n_e}$ by the double unsymmetrical probe (satellite body - spherical electric field probe) leads to the dependence of the parameters of the density $\mathbf{n_e}$ 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. 2.

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