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# THE IONOSPHERE PLASMA STRUCTURAL PARAMETERS INVESTIGATION BY A LANGMUIR CYLINDRICAL PROBE ELIMINATING THE SPACECRAFT FLOATING POTENTIAL INFLUENCE

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***Abstract***

*The paper presents an analysis of some problems due to the influence of the spacecraft floating potential as well as the analyzing voltage at the ionosphere plasma structural parameters investigation by cylindrical Langmuir probe. A computer simulation using a new high-precision method for periodical measurement of the Langmuir cylindrical probe floating potential when measuring the probe collector current is presented. The advantages of the presented method, which is suitable for measurement of all parts of the V-A probe curve, are discussed.*

## 1. Introduction

The spacecraft as a body submersed in plasma is electrostatically charged under the influences of various kinds of currents. In the static state, the spacecraft is charged to some balanced potential $\varphi_B$ where the summary current of the body is $\sum I \approx 0$ [1]. $\varphi_B$ can vary within a wide range taking positive or negative values because the body's surface is under the direct impact of the charged particles streams and electromagnetic radiation. The changes of $\varphi_B$ are a considerable source of errors as they distort the measurements and sometimes make them impossible because the analyzing control voltage U to the Langmuir cylindrical probe (CLP) electrodes is passed in respect to $\varphi_B$. For this reason, three cases are possible:

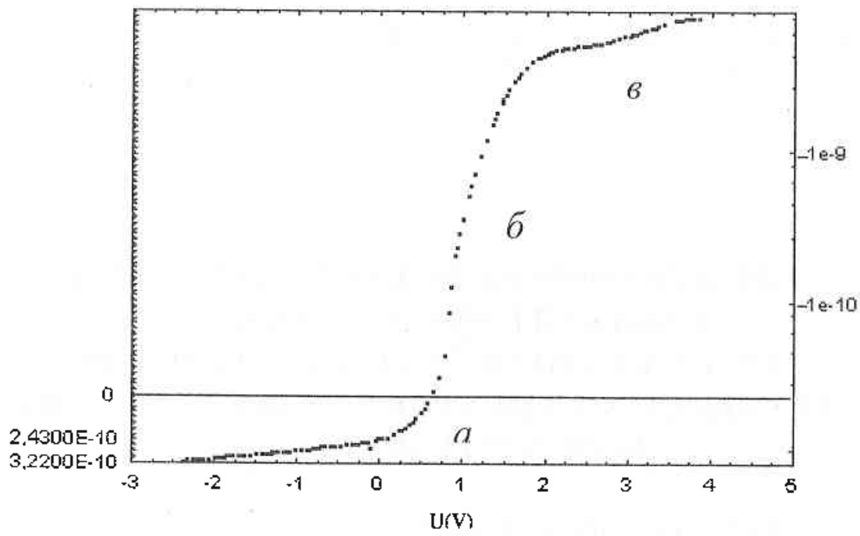


**Fig. 1**

1 – the measured current is positive: this means that $\varphi_в$ is strongly negative and U continues to be all the time negative compared to the plasma.

2 – the measured current is negative: this means that $\varphi_в$ is strongly positive and U continues to be all the time positive compared to the plasma.

In both cases there is no other possibility but to measure the fluctuations of ion and electron density. In such cases we do not use linear voltages but fixed ones to measure current fluctuations. This makes it possible to measure quick density fluctuations having no information about electron temperature.

3 – the measured current changes its sign: in this case, full analysis of the plasma characteristics is possible.

## 2. Space experiments results: some CLP measurement problems

The satellite experiments continue to the end of the satellite's life and the measurements are integral. This makes it possible, on the one hand, to carry out scientific research and, on the other hand, to perform statistical analysis. An ideal V-A curve is shown in Fig. 1. It consists of three typical parts [2]: *а* - ion saturation, *б* - electron retarding and *в* - electron saturation.

The V-A curves from many experiments are shown in Figs. 2, 3 and 4.

Here, two problems can be formulated:

- strong influence of the $\varphi_B$ on the measurements;
- U with constant amplitude and continuance.

In paper [3], the authors present a method for periodical measurement and control of $\varphi_{clp}$.

The method is practically based on two principles:

- From time to time, 16-bit precision measurement and control of $\varphi_{clp}$ for a zero probe current (testing cycle).
- CLP electrodes control by ($U - \varphi_{clp}$) at the time of the next measuring cycle.

## 3. CPL collector current measurement: algorithm and computer simulation.

The structural graph of the CPL collector current measurement algorithm is shown in Fig.5. It includes a testing and a measurement cycle.

In the figure: Io – the current for the analyzing voltage $U=\varphi_{clp} - 4$ V; $I_1$ and $I_2$ – currents from the electron retarding part of the V-A curve; $U_1$ and $U_2$ – corresponding voltages; $c_1$, $c_2$, $c_3$, $c_4$ – constants (determined by digital experiments); $U_{start}$, $U_{end}$, $U_{slope}$ – start, end and limits of U variations.

The next figures 6 (a-f) show a computer simulation of the algorithm operation.

Let plasma density at the start of operation be $N_i=N_e=10^8$ $m^{-3}$, plasma temperature $T_e=1000$ K and ion mass $M_i=16$ a.m.u. ($O^+$) where the satellite's potential is $\varphi_e = 0$ V. In the beginning, we change U from –8 V to +8 V to determine $\varphi_{clp}$ (Fig.6a). $\varphi_{clp}$ is determined on 0,25 V, so we change U from ($\varphi_{clp}$ – 4V) to ($\varphi_{clp}$ + 4V), i.e. from –4,25 V to +3,75 V (Fig.6b). The ion current amplitude is used to determine the two levels of $I_1$ и $I_2$ whose corresponding voltages $U_1$ and $U_2$ will be measured. Now $U_{start}$= –4,25 V and $U_{end}$= +1,28 V (Fig.6b, 6c). The parameters of the next U ($U_{start}$= –1V, $U_{end}$ = +1.28V) already ensure an optimal result (Fig.6b, 6d) and will be repeated unless plasma parameters are not changed critically.

Let the satellite now enter into a region where plasma parameters change suddenly: $N_i=N_e=10^9$ $m^{-3}$, Te=10000 K, $M_i=1$ ($H^+$) and as a result $\varphi_{clp}$ =3V. Naturally, U course will be determined as with the previous curves, i.e. $U_{start}$ = –1,0V, $U_{end}$ = +1,28V (Fig. 6c). The algorithm again operates in the same way: ion current is measured at $U_{start}$, the two levels of currents $I_1$ and $I_2$ are determined and the corresponding levels of $U_1$ and $U_2$ are measured. The parameters of the next U are computed: $U_{start}$ = –5,82V, $U_{end}$ = +4,11V.

Only one step is enough to compute U, covering all three parts of the curves (Fig.6f).

### 4. Results and discussion

An algorithm and computer simulation are developed for:

- a new high-precision method for $\varphi_{clp}$ periodical measurement and control;
- adaptive control of the CLP collector current measurement.

From future space experiments with CLP we expect:

- periodic measurement of the highly-informative parameter $\varphi_{clp}$;
- ultra sensitivity of the measurement tract;
- no switching scales transition processes;
- real V-A curves.

The use of active methods eliminates the necessity of physical phenomena monitoring. So we consider that the presented solutions, which pertain to the passive methods, will be further developed and approved in future. The CLP is included as an important component of the SPACE WEATHER program [4] at the International Space Station, where $\varphi_B$ floats within a wide range ± 300 V.

## References


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# ЕЛИМИНИРАНЕ ВЛИЯНИЕТО НА ПЛАВАЩИЯ ПОТЕНЦИАЛ НА КОСМИЧЕСКИЯ АПАРАТ ПРИ ИЗСЛЕДВАНЕ НА СТРУКТУРНИТЕ ПАРАМЕТРИ НА ЙОНОСФЕРНАТА ПЛАЗМА С ЦИЛИНДРИЧНА СОНДА НА ЛЕНГМЮИР

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**Резюме**

В настоящата работа са анализирани проблемите от влиянието на плаващия потенциал на космическия апарат и анализиращото напрежение при изследване на структурните параметри на йоносферната плазма с цилиндрична сонда на Ленгмюир. Показана с компютърна симулация, използваща нов високоточен метод за периодично измерване на плаващия потенциал на цилиндрична сонда на Ленгмюир при измерване на тока от колектора на сондата. Дискутирани са преимуществата на предложения метод за измерване на всички участъци от волт-амперната характеристика на сондата.