EPSC Abstracts
Vol. 9, EPSC2014-448, 2014
European Planetary Science Congress 2014

Parameters of photoelectrons over the surface of the Moon

S. I. Popel (1-3), A. P. Golub' (1), Yu. N. Izvekova (1-3), V. V. Afonin (2), G. G. Dol'nikov (2), A. V. Zakharov (2), L. M. Zelenyi (2, 3), E. A. Lisin (4), O. F. Petrov (3,4), and V.E. Fortov (4)
(1) Institute of Geosphere Dynamics, Russian Academy of Sciences, Moscow, Russia (e_mail: s_i_popel@mtu-net.ru)
(2) Space Research Institute, Russian Academy of Sciences, Moscow, Russia
(3) Moscow Institute of Physics and Technology (State University), Dolgoprudnyi, Moscow region, Russia
(4) Joint Institute for High Temperatures, Russian Academy of Sciences, Moscow, Russia

Abstract

The existing view of the photoemission properties of lunar regolith does not provide the unambiguous treatment of the parameters and distributions of photoelectrons over the illuminated part of the Moon. This is indicated by the present calculations of the density, temperature, and distribution function of photoelectrons. It has been demonstrated that the quantum yield of lunar regolith is the main parameter determining the generation of photoelectrons near the surface of the Moon. At present, this parameter is determined with significant uncertainty. The measurement of the quantum yield of regolith directly on the surface of the Moon has been proposed as a variant of the solution of the indicated problem. Such measurements can be performed in the framework of future lunar missions.

1. Introduction

The Luna-25, Luna-26, Luna-27, Luna Sample Return, etc., missions are under preparation in Russia. The landing modules of the Luna-25 and Luna-27 spacecrafts are planned to be equipped with instruments for studying the properties of the dusty plasma over the surface of the Moon. The upper part of an electric-field sensor ES on the landing modules of the Luna-25 and Luna-27 is an analog of a classical Langmuir probe, which will record primarily the properties of photoelectrons. For successful measurements, the expected parameters of photoelectrons should be taken into account when developing electric-field sensors. However, the calculation of these parameters faces difficulties that can be eliminated only through direct experiments. We calculate the parameters of photoelectrons near the surface of the Moon, discuss difficulties in the determination of their values, and describe experiments that are necessary within future lunar missions.

2. Number densities and temperatures of photoelectrons

Photoelectrons appear near the surface of the Moon primarily from the surface itself at its interaction with solar radiation. The spectrum of solar radiation, quantum yield, and work function of lunar regolith are important parameters for the calculation of the distribution function, density, and temperature of photoelectrons. It is assumed that the typical work function for lunar regolith is within the range of 5–6 eV. The quantum yield determining the number of electrons knocked out from the surface by one photon is a very important parameter requiring further refinement.

The parameters of photoelectrons near the equator in the near-surface layer of the illuminated part of the Moon are calculated [2]. Table 1 shows the values of the number density N_0 and temperature T_e of photoelectrons for the solar activity level corresponding to (column I) an X28 Class solar flare, (column II) the solar maximum, and (column III) the solar minimum for various quantum yields [4] and [5]. The calculated characteristics of photoelectrons near the surface of the Moon are strongly different. The dependence of the parameters N_0 and T_e on the solar activity level is not so strong. The difference between the quantum yields presented in [4] and [5] much more strongly affects the calculation than the variation of the work function in the range of 5–6 eV.

Table 1: Parameters of photoelectrons in the near-surface layer of the illuminated part of the Moon for various solar activity levels and various quantum yields

	I	II	III
N_{01}, cm^{-3}	$2.2\cdot10^5$	$2.1\cdot10^5$	$1.9\cdot10^5$
T_{e1}, eV	0.2	0.1	0.1
N_{02}, cm^{-3}	$8.6\cdot10^2$	$2.9\cdot10^2$	$1.3\cdot10^2$
T_{e2}, eV	2.1	1.9	1.3

3. Experimental scheme

It is very difficult to ensure the delivery of lunar soil so as to avoid its interaction with the Earth's atmosphere. In view of this circumstance, the measurement of the quantum yield and work function of lunar regolith directly on the surface of the Moon within the future Luna-27 mission seems promising.

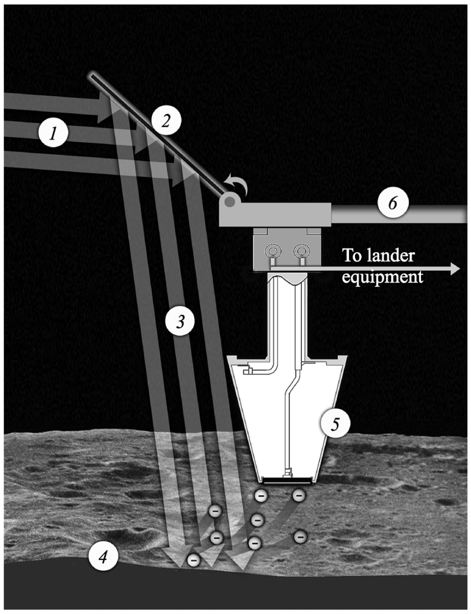

Figure 1: Layout of the experiment.

A possible layout of an experiment on the measurement of the quantum yield and work function of lunar regolith is shown in Figure 1. Electromagnetic radiation (1) comes from the Sun. An optical channel consisting of a mirror (2) and/or an optical cable is used to create the redirected photon beam (3). On one hand, the mirror modifies the radiation spectrum, which should be taken into account when analyzing the final results. On the other hand, this mirror can be used to enhance (by several times) the radiation interacting with the surface of the Moon. This will provide more reliable experimental results. The Langmuir probe (5) can detect the photoelectron flux with a step of about 0.05 V in the range from –100 to 100 V both in the presence of a light source illuminating the surface of the Moon and in the absence of such a source, detecting the energy spectrum of electrons. The energy spectrum of electrons correlates in turn with the current–voltage characteristic of the Langmuir probe. Comparison of the current–voltage characteristics obtained in the presence and absence of illumination of the surface of the Moon makes it possible to determine the quantum yield and work function of lunar regolith.

4. Summary and Conclusions

In summary, although certain success was achieved in the description of dust and the plasma–dust system near the Moon, there is a number of important questions that should be answered. In particular, the quantum yield of lunar regolith has significant importance for the calculations of the parameters of the plasma–dust system. The scheme of the experiments for measurement of the quantum yield of regolith directly on the surface of the Moon has been presented.

Acknowledgements

This work was supported by the Presidium of the Russian Academy of Sciences (program no. 22 "Fundamental Problems of Research and Exploration of the Solar System") and by the Russian Foundation for Basic Research (project nos. 12-02-00270-a).

References

[1] A. P. Golub', G. G. Dol'nikov, A. V. Zakharov, L.M. Zelenyi, Yu. N. Izvekova, S. I. Kopnin, and S. I. Popel, Dusty Plasma System in the Surface Layer of the Illuminated Part of the Moon, JETP Letters, Vol. 95, No. 4, pp. 182-187, 2012.

[2] S. I. Popel, A. P. Golub', Yu. N. Izvekova, V. V. Afonin, G. G. Dol'nikov, A. V. Zakharov, L. M. Zelenyi, E. A. Lisin, and O. F. Petrov: On the distributions of photoelectrons over the illuminated part of the Moon, JETP Letters, , Vol. 99, No. 3, pp. 115–120, 2014.

[3] S. I. Popel, S. I. Kopnin, A. P. Golub', G. G. Dol'nikov, A. V. Zakharov, L. M. Zelenyi, and Yu. N. Izvekova, Dusty Plasma at the Surface of the Moon, Solar System Research, Vol. 47, No. 6, pp. 419-429, 2013.

[4] E. Walbridge: Lunar Photoelectron Layer, J. Geophys. Res. Vol. 78, pp. 3668-3687, 1973.

[5] R. F. Willis, M. Anderegg, B. Feuerbacher, and B. Fitton: Photoemission and Secondary Electron Emission from Lunar Surface Materials. in Photon and Particle Interactions With Surfaces in Space, Ed. by R. J. L. Grard (Reidel, Dordrecht,), pp. 389-401, 1973.