Accepted Manuscript

Numerical modelling of the Luna-Glob lander electric charging on the lunar surface with SPIS-DUST

I.A. Kuznetsov, S.L.G. Hess, A.V. Zakharov, F. Cipriani, E. Seran, S.I. Popel, E.A. Lisin, O.F. Petrov, G.G. Dolnikov, A.N. Lyash, S.I. Kopnin

PII: S0032-0633(17)30269-6

DOI: 10.1016/j.pss.2018.03.004

Reference: PSS 4489

To appear in: *Planetary and Space Science*

Received Date: 31 July 2017

Revised Date: 1 March 2018

Accepted Date: 1 March 2018

NUMERICAL MODELLING OF THE LUNA-GLOB LANDER ELECTRIC CHARGING ON THE LUNAR SURFACE WITH SPIS-DUST

I.A. Kuznetsov[(1)], S.L.G. Hess[(2)], A.V. Zakharov[(1)], F. Cipriani[(3)], E. Seran[(4)], S.I. Popel[(1)], E.A. Lisin[(5)], O.F. Petrov[(5)], G.G. Dolnikov[(1)], A.N. Lyash[(1)], S.I. Kopnin[(1)]

[(1)]Space Research Institute of the RAS, Moscow, Russia, email:kia@iki.rssi.ru
[(2)]French Aerosp. Lab., ONERA, Toulouse, France
[(3)]ESTEC/TEC-EES, Noordwijk, The Netherlands
[(4)]Laboratoire Atmospheres, Milieux, Observations Spatiales/UVSQ/UPMC, Paris, France
[(5)]Joint Institute for High Temperatures of the RAS, Moscow, Russia

Abstract

One of the complicating factors of the future robotic and human lunar landing missions is the influence of the dust. The upper insulating regolith layer is electrically charged by the solar ultraviolet radiation and the flow of solar wind particles. Resulted electric charge and thus surface potential depend on the lunar local time, latitude and the electrical properties of the regolith.

Understanding of mechanisms of the dust electric charging, dust levitation and electric charging of a lander on the lunar surface is essential for interpretation of measurements of the instruments of the Luna-Glob lander payload, e.g. the Dust Impact sensor and the Langmuir Probe.

One of the tools, which allows simulating the electric charging of the regolith and lander and also the transport and deposition of the dust particles on the lander surface, is the recently developed Spacecraft Plasma Interaction Software toolkit, called the SPIS-DUST.

This paper describes the SPIS-DUST numerical simulation of the interaction between the solar wind plasma, ultraviolet radiation, regolith and a lander and presents as result qualitative and quantitative data of charging the surfaces, plasma sheath and its influence on spacecraft sensors, dust dynamics. The model takes into account the geometry of the Luna-Glob lander, the electric properties of materials used on the lander surface, as well as Luna-Glob landing place. Initial conditions are chosen using current theoretical models of formation of dusty plasma exosphere and levitating charged dust particles.

Simulation for the three cases (local lunar noon, evening and sunset) showed us the surrounding plasma sheath around the spacecraft which gives a significant potential bias in the spacecraft vicinity. This bias influences on the spacecraft sensors but with SPIS software we can estimate the potential of uninfluenced plasma with the data from the plasma sensors (Langmuir probes). SPIS-DUST modification allows us to get the dust dynamics properties. For our three cases we've obtained the dust densities around the spacecraft and near the surface of the Moon. As another practical result of this work we can count a suggestion of improving of dusty plasma instrument for the next mission: it must be valuable to relocate the plasma sensors to a distant boom at some distance from the spacecraft.

***Index Terms*— Moon, regolith, lander, plasma, dust electric charging, dust levitation**

1. INTRODUCTION

The images and direct observations of the lunar horizon glow made almost 50 years ago by the Surveyor-7 (Rennilson and Criswell, 1974) and Apollo-17 astronauts (Zook and McCoy, 1991), stay today in our mind as one of the most mysterious observations related to Moon and are still under debate. *Stubbs at al. (2006) stated that surface electric charging in particularly near the lunar terminator might result in the levitation of the lunar dust grains with radii less than 10 μm. Straightforward levitation mechanism explanation is based on the idea that the electrically charged surface and electrically charged dust grains repel each other. Under the action of electrostatic forces, the ~10 μm grains are predicted to levitate from the lunar surface and to stay suspended near the surface (Sickafoose et al., 2002), while the ~1 μm grains may escape the lunar gravity in the case they reached the escape velocity which is 2,38 km/s for the Moon's equator (Heiken et al., 1991). Such grains were observed up to an altitude of ~10 km and higher (Stubbs et al., 2006, Horanyi et al., 2104a, 2014b). The novel work by Wang et al. (2016) proposes the so-called "Patched charge model" where the main trigger for the dust particles lifting off is explained as highly negative charged surfaces in micro-cavities in the regolith.* Rennilson and Criswell (1974) *found* the *5 μm grains suspended at ~10 cm above the surface. During the Apollo missions, ~0.1 μm dust particles were observed in the lunar exosphere at the*