LABORATORY STUDY OF PLASMA CHARGING INSIDE LAVA TUBES ON THE LUNAR SURFACE.

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Introduction: Lava tubes are imaged by the Kaguya (SELENE) and Lunar Reconnaissance Orbiter (LRO) spacecraft. The depth and opening of these tubes are estimated to be 50 – 100 m with the ratio of the depth to the opening radius much larger than those of typical impact craters [1,2]. In addition to their scientific values for geological studies, as humans are returning to the Moon for a long-term presence, lava tubes may have good potential to be used as natural habitats. It is thus important to understand the particles and fields environment inside the tubes to assess any potential charging hazards for habitation.

Currently, the electrical environment in a lava tube was only studied by computer simulations [3,4]. A recent simulation shows that the surface potential may reach highly positive values at the bottom of the tube which depth is 4 times of its opening radius [4]. Here we present the first laboratory studies of the charging environment inside lava tubes using the Colorado Solar Wind Experiment (CWSE) device at the IMPACT lab at the University of Colorado Boulder [5].

Experiment and Results: The experimental setup is placed at the center of the CSWE chamber, which produces a simulated solar wind plasma with energies ranging from 100 eV to 800 eV and current densities ranging from 5 mA to 80 mA (Fig. 1). The experimental setup consists of a delrin surface with a stainless-steel plate attached anti-parallel to the simulated plasma flow. It is biased between -20 V and -70 V (Fig. 2). A glass tube with a diameter of 6 mm is attached to the surface, with a disk-shaped Langmuir probe placed at the bottom with depths ranging from 0 mm to 24 mm. The Langmuir probe is used to measure the floating potential or the current-voltage (I-V) curves characterizing the plasma at the bottom of the tube.

The experiment shows that the bottom of the tube is positively charged but not as positive as the solar wind ion energy as shown in the computer simulations [4]. It is shown that secondary electrons may be created from energetic ion impacts on the wall of the tube and accelerated to the positively charged bottom surface, resulting in the reduced charge.

The potential of the bottom surface increases with the depth of the tube, showing that the solar wind electrons are collected on the tube wall as they move along the narrow tube towards the floor.

Summary: The laboratory experiment shows moderate positive charging on the bottom of a narrow tube facing the simulated solar wind plasma. Our results indicate that lunar lava tubes may be used for natural habitats for future surface exploration.

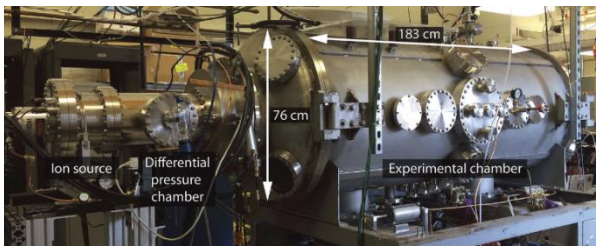

Figure 1 - A photo of the CSWE chamber [5]

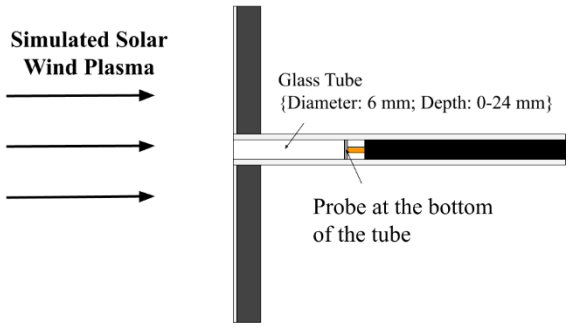

Figure 2 - A schematic diagram of the experimental setup in the CSWE chamber

References: [1] Haruyama et al (2009), Geophys. Res. Lett., 36, L21206; [2] Robinson et al (2012), Planet. Space Sci., 69, 18–27; [3] Miyake and Nishino (2015), Icarus, 260, 301; [4] Nakazono and Miyake (2023), J. Geophys. Res.: Planets, 128, e2022JE007589; [5] Ulibarri et al (2017), Rev. Sci. Instrum., 88, 115112.