2009 AGU Fall Meeting: December 14-18, San Francisco, CA P23C-1256

Lunar Photoemission Studies with a Xe Excimer UV Lamp

Shannon Dickson, Scott Robertson, Addrienne Dove, Tobin Munsat, Xu Wang, and Zoltan Sternovsky

Colorado Center for Lunar Dust and Atmospheric Studies, University of Colorado, Boulder, CO 80309

Abstract

Solar illumination creates a photoelectron sheath above surfaces in space. For example, the surface of the Moon is thought to have a photoelectron sheath with a thickness of ~1 m that charges dust on the surface causing the dust to transport horizontally. In the laboratory, it is difficult to create a photoelectron sheath with dimensions smaller than the vacuum chamber using standard illumination sources and metallic surfaces. We have used a xenon excimer lamp (Osram Xeradex) generating 9 W at 172 nm to create a photoelectron sheath above a Zr surface. We find a photoemission of 1 μA/cm^2 at 10 cm radial distance from the lamp in vacuum, which corresponds to a sheath scale length of ~5 cm with an assumed photoelectron temperature of 2eV. Standard emissive probe methods are being evaluated as a possible means of determining the sheath potential profile in this low-density one-component plasma.

Background

The lunar horizon glow, shown in the figure below, is a prime example of the dusty plasma conditions on the lunar surface. Solar UV radiation is known to cause photoemission from the lunar surface with a likely emission current of 5-40μA/m^2 depending on solar conditions[1]. The resulting surface charging leads to a positive surface potential of a few volts[2]. The plasma conditions and dust transport near terminator regions as well as the affect of charging on lunar dust adhesion are of particular interest.

References

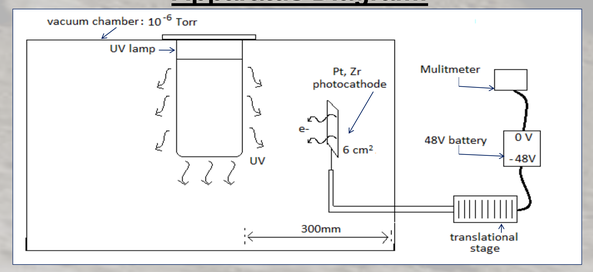
(1) Sternovzky et al., Journal of Geophysical Research, 113, A10104 (2008).

(2) Manka, R. H., Plasma and potential at the lunar surface, in Photon and Particle Interaction with Surfaces in Space, edited by R.J.L Grard, p. 347-361, Reidel, Dordrecht-Holland, 1973b.

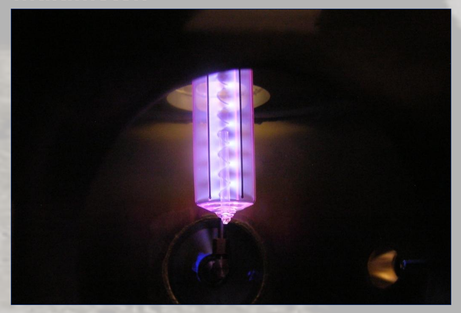
UV Lamp Characterization

The UV emission from the lamp is characterized by exposing a zirconium and a platinum surface to the operating lamp and measuring the resulting photoemission from the photocathodes individually. Zirconium is selected as a surface with high photoelectron yield and platinum, with a quantum efficiency of 1.1 x 10^{-3}, is used as a calibration surface.

Apparatus Diagram:



The UV lamp is operated in 10^{-6} Torr vacuum. A negatively biased photocathode probe (6cm^2) is mounted on a translational stage to vary its radial distance from the lamp. The resulting photoelectron current is measured using a multimeter.

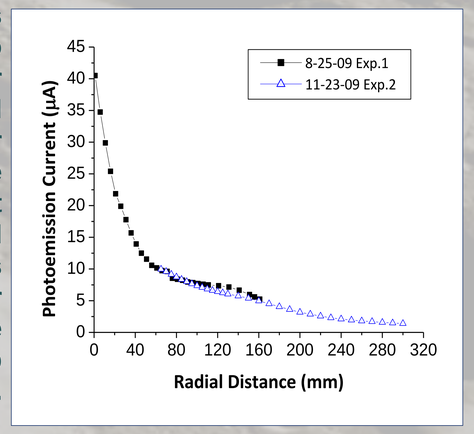


UV Lamp in Operation:

This Xe Excimer UV Lamp emits 9W at 172nm, making it a suitable candidate for generating a photoelectron sheath smaller than the vacuum chamber.

Measured Photoemission Current from the Photocathode with Distance from the Lamp:

Two separate UV lamps have been tested to characterize their emission. Measured photoemission from Zr using each lamp are shown on the plot at the right. The second experiment (blue) was conducted in a larger chamber and the range of the distance sweep was thus extended. The results for each lamp show consistent UV emission between the lamps.



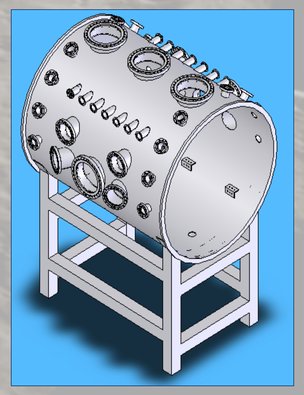
Experiment Conclusions

With the Pt photocathode at a distance of 10cm, we find a photoemission of 1 μA/cm^2. This corresponds to 9W of UV emission and a photoelectron sheath scale length of approximately 5cm with an assumed photoelectron temperature of 2eV. The sheath scale is small enough to allow measurements of the potential profile. Multiple lamps can be used to make measurements for a larger photoemitting area. Lunar regolith has a quantum efficiency on the order of 10^{-5}. Lunar regolith simulant can be placed on a highly photoemitting surface such as Zr to analyze lunar surface charging and dust transport due to the presence of the photoelectron sheath.

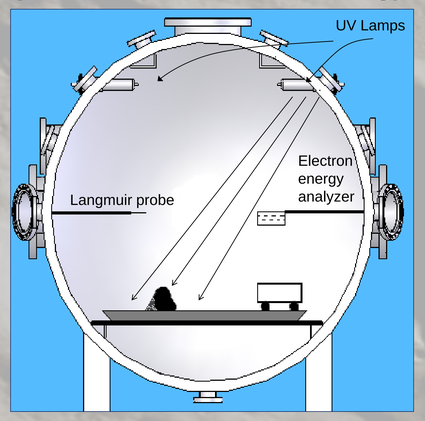
Upcoming Experiments

The Lunar Environment and Impact Laboratory (LEIL)

The LEIL chamber, designed for the CCLDAS Lunar Science Institute, is a cylindrical vacuum chamber 6 feet long, and 4 feet in diameter. It has 48 various ports for experiment versatility. The chamber supports up to 14 Xe excimer UV lamps to create a photoelectron sheath over a large area (~1 m^2). Plasma conditions on the simulated lunar surface will be examined using a large tray of lunar regolith simulant.



The photoelectron sheath above the photoemitting metal and regolith surface will be analyzed using Langmuir probes and an electron energy analyzer.



Surface features such as boulders and craters will be simulated to investigate sheath conditions and dust transport at regions between shaded and photoemitting surfaces. Mini-rovers will also be used to examine dust adhesion in a quiescent and disturbed dusty plasma environment.

LEIL Chamber delivery is scheduled for April 2010 and experiments will commence in June 2010.