URSI AP-RASC 2019, New Delhi, India, 09 - 15 March 2019

Lunar Photo-electron sheath and fine particle levitation

S. K. Mishra* and A. Bhardwaj
Physical Research Laboratory (PRL), Ahmedabad 380009, India,
E-mail: sanjaym@prl.res.in; ABhardwaj@prl.res.in

The observation of lunar horizon low and streamers over moon surface by Apollo lunar missions [1] were the first signature of dusty environment on the moon where sunlight scattering is primarily caused by charged dust particles originating from lunar surface [2]. The moon surface and fine particles acquire charge under direct exposure of the solar radiation and wind plasma, giving rise to the phenomena of the sheath formation and dust levitation [3]. The earlier studies/ observations [4] suggest the electron sheath span up to 10's meter while sub-micron (~100 nm) grains are noticed to float up to (~1–100) cm lunar altitude, particularly in sunlit zone.

In this brief presentation, the formation of photoelectron sheath over the lunar surface and subsequent fine dust levitation, under irradiation of solar wind plasma and continuous solar radiation spectrum has analytically been formulated. The photoelectron sheath characteristics using Poisson's equation, configured with the population density contribution from half Fermi Dirac distribution of the photoemitted electrons has been evaluated; as a consequence, altitude (& latitude) profiles for electric potential, electric field and population density within photoelectron sheath have been derived. It is noticed that the lunar photoelectron sheath is a significant function of wind plasma, surface temperature, surface material and solar radiation spectrum. Photoelectron sheath is noticed to be sharper at equator in comparison to as we approach towards the pole while the electron density in the sheath is noticed to sustain at higher lunar altitudes for larger latitudes (around poles) though the electron density is quite low. The analytical prediction of electron sheath span is noticed to be consistent with the observed altitude profiles for the electron density [5–6].

Next, the expression for accretion rate of sheath electrons over the levitated spherical particles using anisotropic photoelectron flux has been derived which has further been utilized to characterize the charging of levitating fine particles in the lunar sheath alongwith other constituent photoemission and solar wind fluxes. This estimate of particle charge has further been manifested with lunar sheath characteristics to evaluate the altitude profile of the particle size exhibiting levitation through the balance of electrostatic force with lunar gravity. The analysis predicts that the submicron particles may sustain couple of meters in equilibrium. For instance, for instance, a 500 and 100 nm particles are predicted to float up to ~10 cm and ~100 cm respectively in the photoelectron sheath at equator (0^o latitude) while a 300 and 50 nm fine dust particles are predicted to float up to ~10 cm and ~175 cm respectively in the sheath at 70^o latitudes. It is interesting to note that these fine particles are noticed to acquire charge up to ~ (3.6 – 4.2) V and literally in floating phase at equilibrium condition. Since the analysis infers steady state features, submicron charged particles which eventually dominate in the distribution, may be harmful to the rover operation in Ch-2 campaign in terms of optical visibility and electrostatic interaction with its surface. The parametric dependence of the sheath structure and particle levitation altitude profiles on the wind plasma parameters, latitude and lunar surface parameters has been discussed and graphically presented. The work is of practical significance in designing test experiments in labs for future lunar/ space campaigns.

References

[1] J. J. Rennilson and D.R. Criswell, "Surveyor observations of lunar horizon-glow", *Moon* **10**, 1974, 121-142, doi: 10.1007/BF00655715

[2] H. Zook and J. Mc. Coy, "Large scale lunar horizon glow and a high altitude lunar dust exosphere", *Geophys. Res. Lett.*, **18**, 1991, 2117-2120, doi: 10.1029/91GL02235

[3] J. E. Colwell, S. Batiste, M. Horanyi and S. Store, "Lunar surface: Dust dynamics and regolith mechanics", 2007, *Rev. of Geophys*. **45**, RG2006, doi: 10.1029/2005RG000184

[4] S. A. Stern, "The lunar atmosphere: History, status, current problems, and context" *Rev. Geophys.* **37**, 1999, 453-491, doi: 10.1029/1999RG900005

[5] R. R. Vondrak, "Lunar base activities and the lunar environment", 1992, *Presented at Lunar Bases and Space Activities in the 21st Century*", **01**, 337-345, doi: 19930008266.