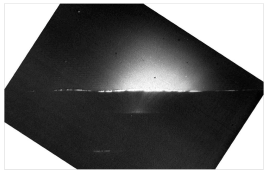

Modeling Dust Clouds on the Moon

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Summary

- Surveyors 5, 6, and 7 observed forward scattered light after sunset
  - Most probable explanation is a dust cloud levitated in the plasma sheath
- 1D hybrid code with fluid plasma and particle dust grains is developed
  - Matches results from [1] showing saturated dusty plasma sheaths
  - Future models will include additional complexity

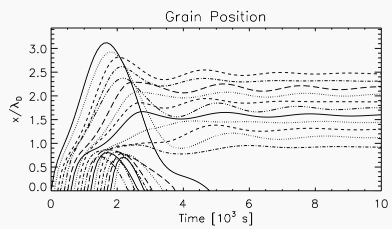

Figure 1. Dust trajectories in a saturated dust sheath

Horizon Glow: Surveyors 5, 6, and 7 captured the first evidence of dust transport on airless bodies with their television cameras (**Figure 2**). Just after sunset, a horizon glow was observed above the western horizon. This was interpreted to be forward scattered light from a cloud of dust particles with radii ~5 µm, vertical dimension ~3-30 cm, and horizontal dimension ~14 m [2].

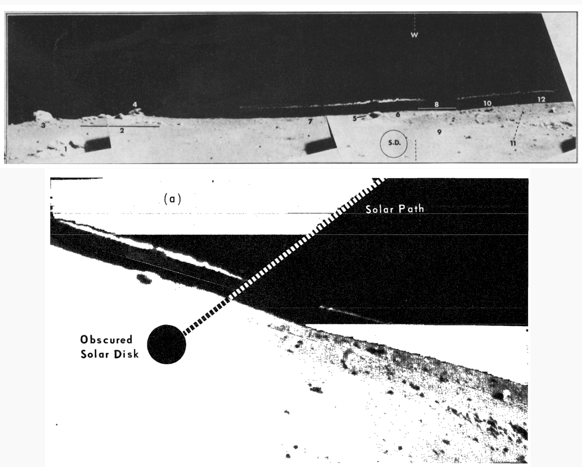

Figure 2. Surveyor 7 compilation images showing horizon glow just after local sunset [2,3].

Dust Levitation: Due to surface charging, like charged grains on the surface electrostatically repel each other. If this force overcomes gravity and cohesion forces, these grains can be lofted into the plasma sheath above the surface. In this model, grains are injected into the sheath with optimal velocities for levitation. To model the plasma sheath, a two fluid approach is used with Boltzmann electrons and cold, drifting ions [4]:

$$n_e = n_0 e^{e\varphi/kT_e} \qquad n_i = n_0\left(1 - \frac{2e\varphi}{m_i v_{i,dr}^2}\right)^{-1/2}$$

As grains traverse the sheath, they charge according to charging currents dependent on the local plasma conditions and grain charge [5]:

$$I_e = -n_0 e\pi a^2\sqrt{\frac{8kT_e}{\pi m_e}}\exp\left(\frac{e\varphi}{kT_e}\right)\exp\left(\frac{eQ}{4\pi\epsilon_0 a kT_e}\right)$$

$$I_i = n_0 e\pi a^2 \varphi_{i,dr}\left(1 - \frac{eQ}{2\pi\epsilon_0 a(v_{i,dr}^2 m_i - 2e\varphi)}\right)$$

Given certain conditions such as initial velocity, grain size, and initial charge, grains have been shown to levitate in stable equilibria in the plasma sheath [4] as seen in **Figure 3**.

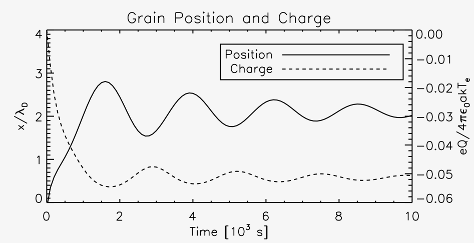

Figure 3. Dust levitation in a plasma sheath

Simulation: If enough grains collect in the plasma sheath, the sheath potential profile can be significantly altered [1]. A 1D hybrid code has been developed with fluid plasma and particle dust grains to better understand this phenomena. Launching dust grains into the sheath, Poisson's equation is solved at each time-step to determine the new potential, charging currents, and forces experienced by each grain.

$$\frac{\partial^2\varphi}{\partial x^2} = \underbrace{\frac{en_0}{\epsilon_0}e^{e\varphi/kT_e}}_{\text{electrons}} - \underbrace{\frac{en_0}{\epsilon_0}\left(1 - \frac{2e\varphi}{m_i v_{i,dr}^2}\right)^{-1/2}}_{\text{ions}} - \underbrace{\frac{\rho_d(x)}{\epsilon_0}}_{\text{dust}}$$

Results: Identical particles are injected into the sheath at a given cadence. As more grains become suspended in the sheath, the sheath potential is modified and the electric field is weakened. At a critical dust density, the sheath becomes saturated and can no longer support the suspension of additional grains [1]. An example run from the simulation is shown in **Figures 1, 3**.

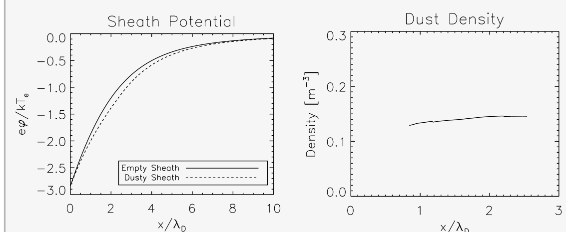

Figure 3. Dust trajectories, potential, and grain density in dust sheath

In a different run, the spatial extent of the dust sheath is found to vary as electron temperature varies (**Figure 4**) due to different electron charging currents.

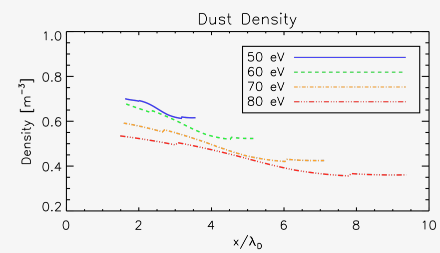

Figure 4. Dust sheath

Future Work: Having checked the model against the results from [1], additional layers of complexity will be added:

- Allow for different grain size distributions
- Change ion distribution to drifting Maxwellian
- Extend to 2D/3D to include topographical effects

[1] Nitter, T., *et al.*, IEEE Trans. Plasma Sci., **22,** 1994
[2] J. Rennilson and D. Criswell, The Moon, **10**, 1973
[3] Criswell, D.R. Proc. Lunar Sci. Conf., 3rd, 1972
[4] Nitter, T., *et al.*, Earth, Moon and Planets, **56,** 1992
[5] Havnes, O., *et al*, J. Geophys. Res. **2**, 2281-2287