固体天体表層の帯電環境の計算とその応用

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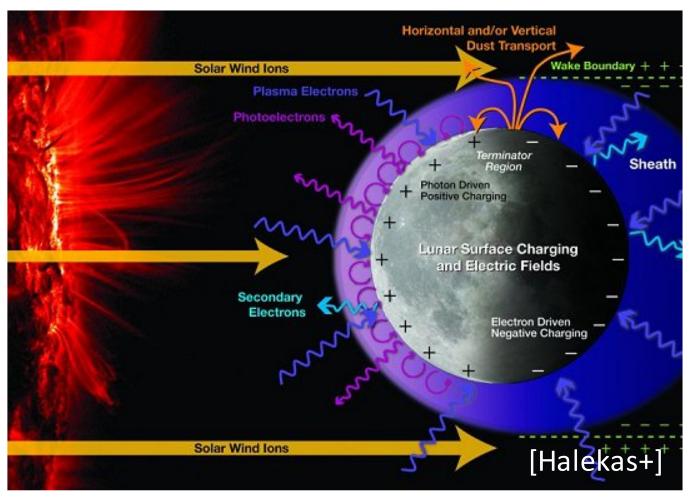
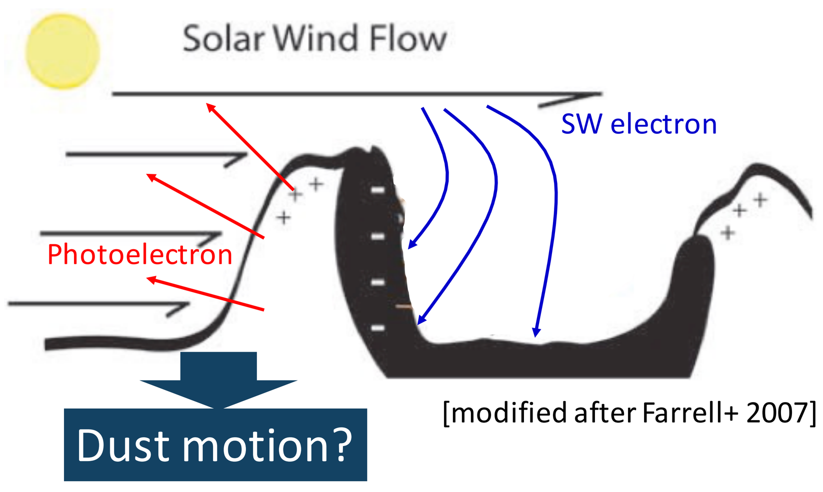
Electric & dust environment near moon surface

Surface charging as a result of interactions among solar wind, photoelectron, and moon surf.

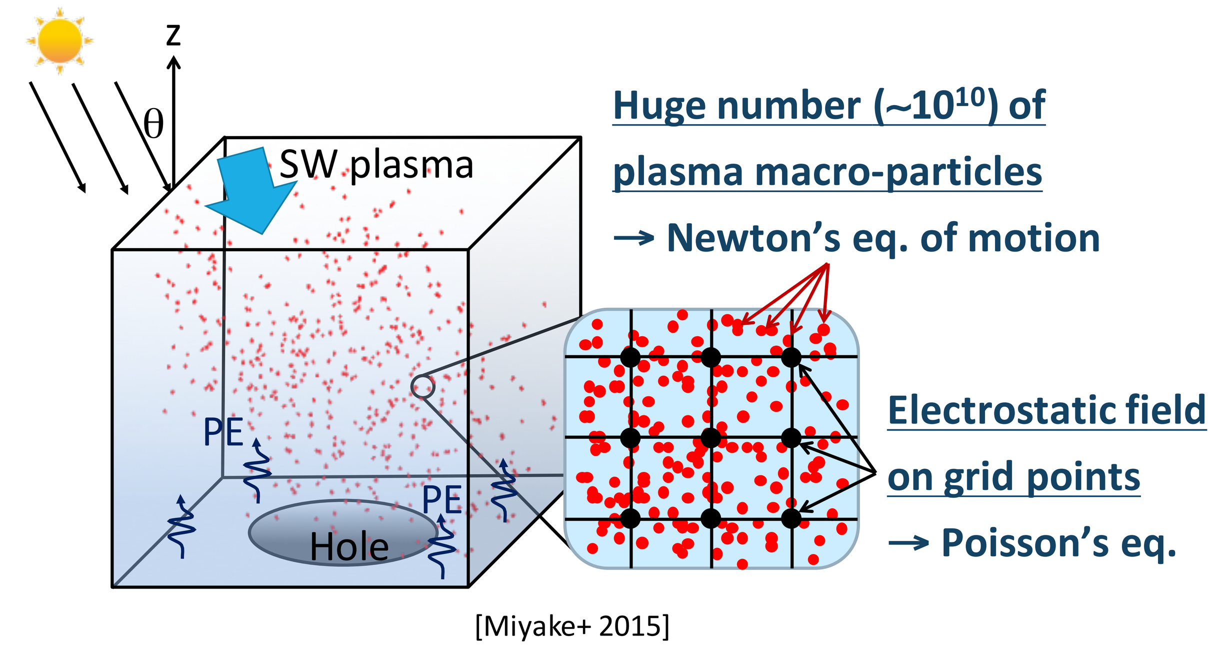
Global Scale



Local scale



3D particle simulations on plasma dynamics



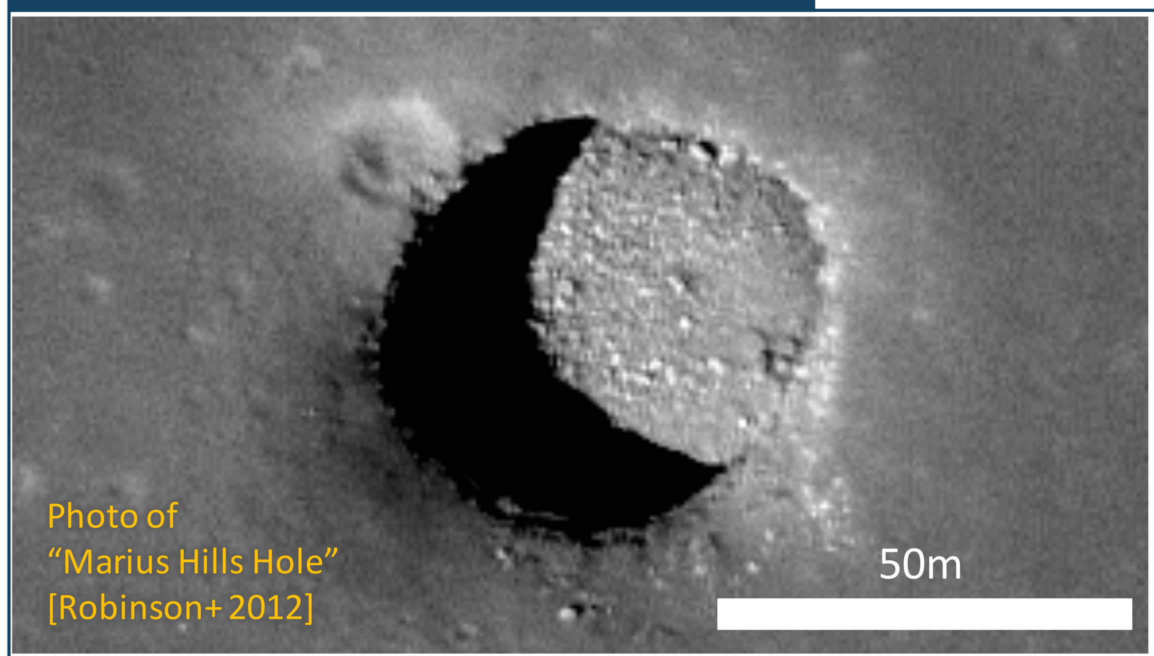
Huge number (~10^{10}) of plasma macro-particles
→ Newton's eq. of motion

Electrostatic field on grid points
→ Poisson's eq.

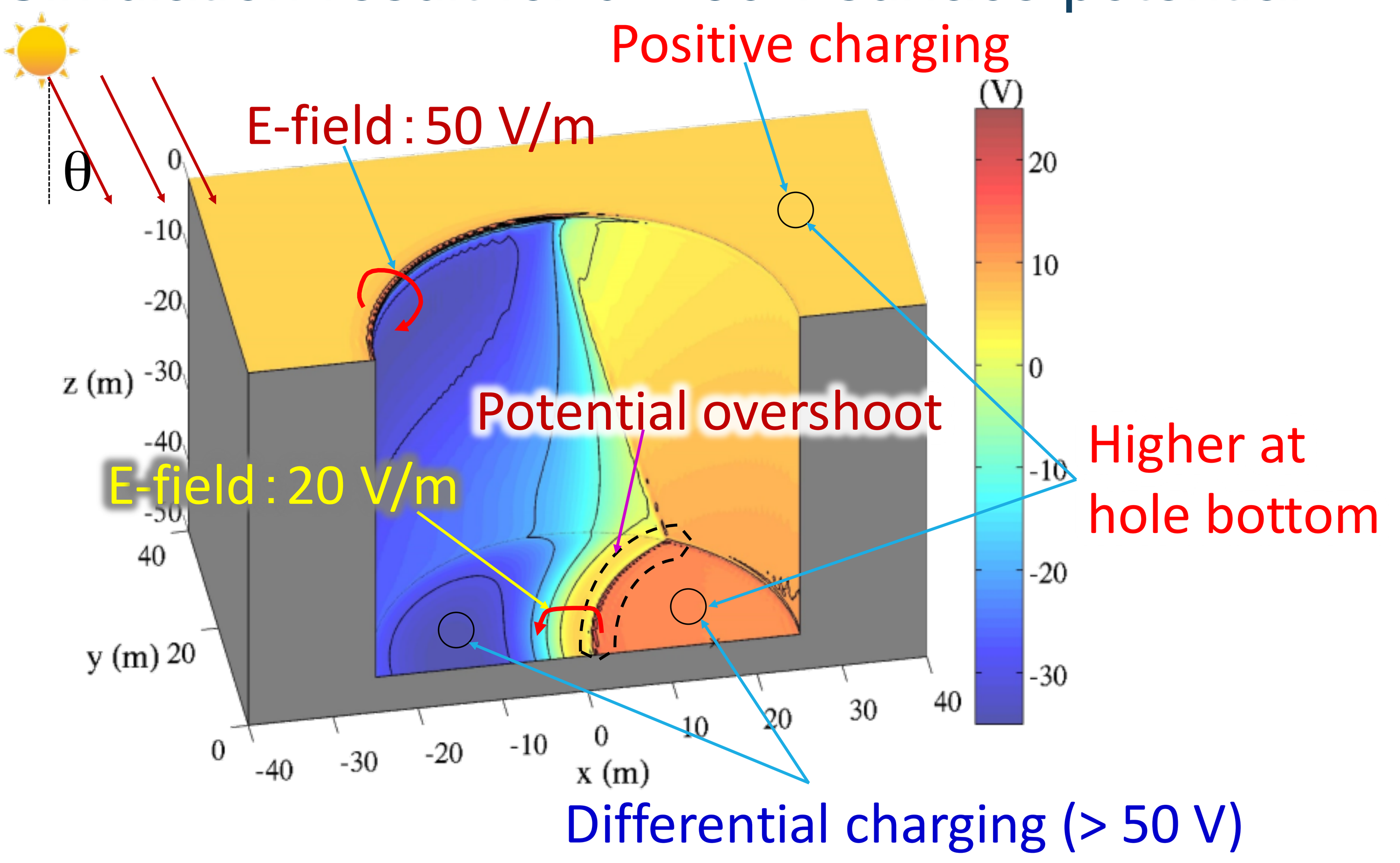
We consider...

1. SW: Solar wind plasma (5 /cc, 10 eV, 450 km/s) downflow
2. PE: Photoelectron (4.5 μA/m², 2.2 eV) emission
3. Plasma captured at electrically-insulating lunar surface

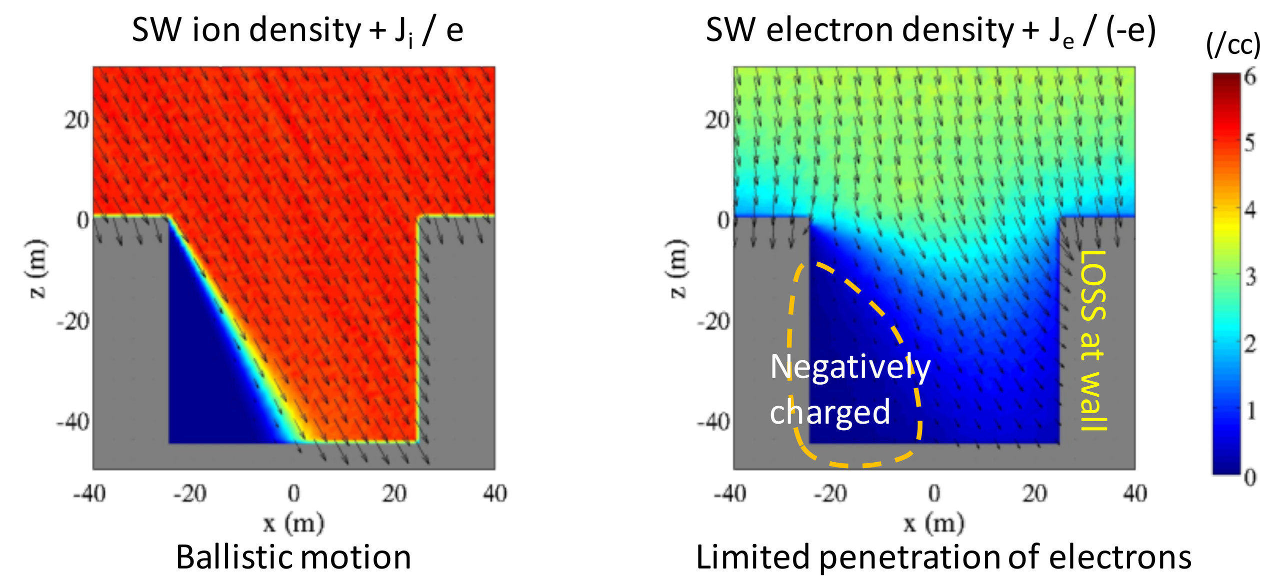
Lunar vertical holes



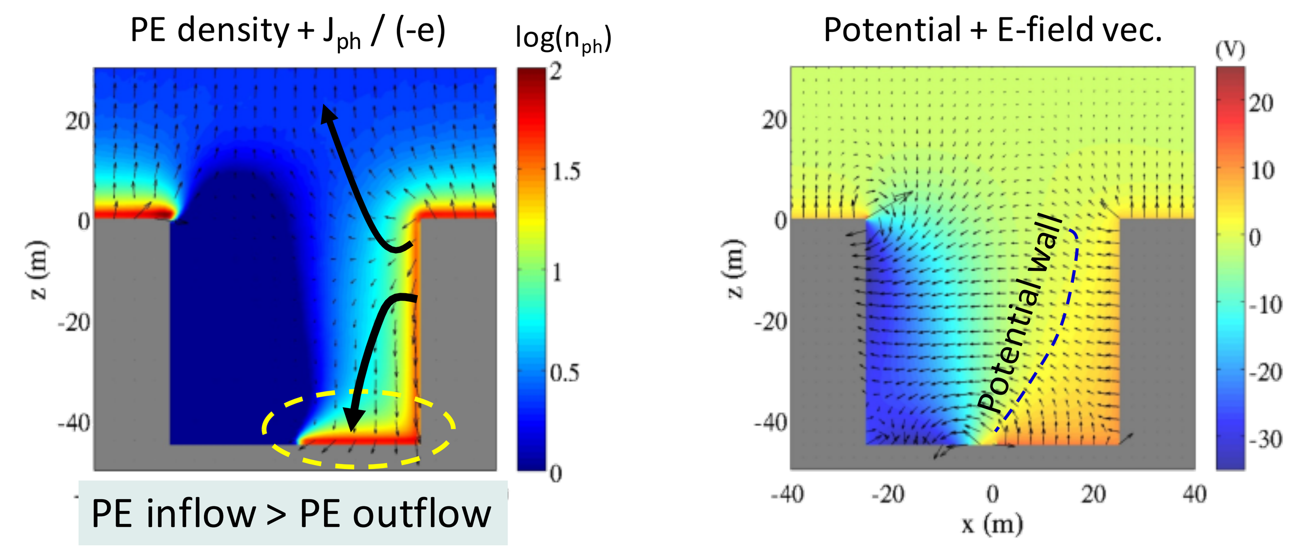
Simulation result for θ = 30°: surface potential



Plasma environment near hole



$J_i > J_e$ → Higher potential at hole bottom



(SW protons) ballistic motion, due to supersonic flow & large mass

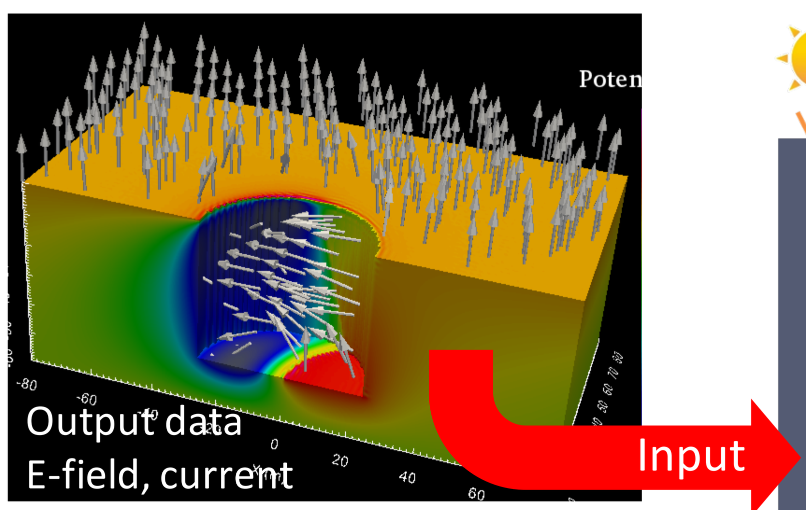
(SW electrons) limited access into the hole due to...

1. negatively potential at shadow region
2. electron loss at the sunlit wall, with positive (attracting) potential

(PE) emitted from vertical wall and going down to the hole bottom

Simulations of lunar dust charging & dynamics

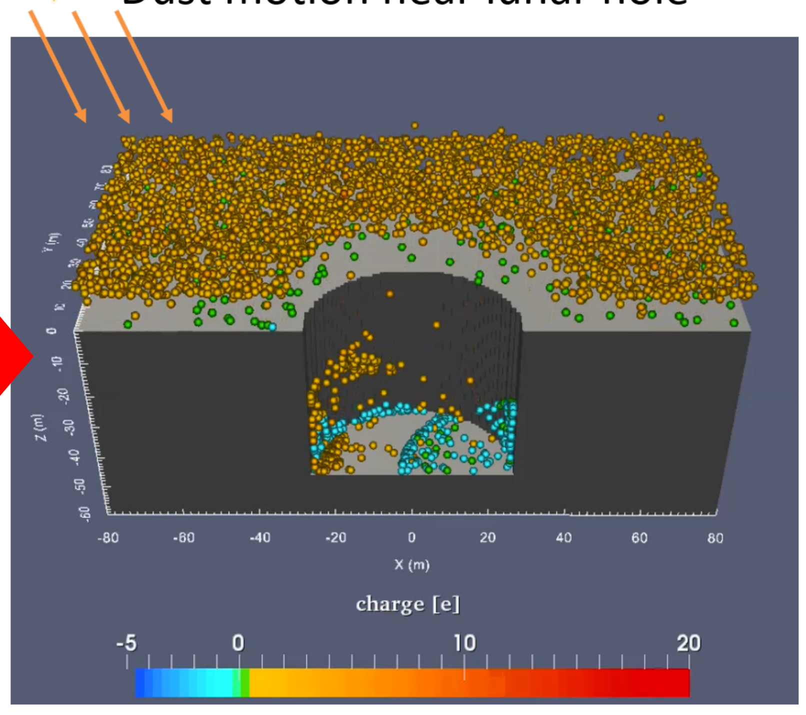
1. Electric env. from plasma simulations



Radius: r_d	20 nm
Mass density: ρ_d	2.5 g/cm³
Initial vel.: v_0	1 m/s
Initial charge: q_0	±1 e[C]
Gravity: g	1.6 m/s²

2. Dust charging & dynamics

Dust motion near lunar hole



Numerical description

1. Equation of motion for charged dust grains (considering electric & gravitational forces)

$$\frac{d\boldsymbol{x}}{dt} = \boldsymbol{v}$$

$$\frac{d\boldsymbol{v}}{dt} = \frac{q_d}{m_d}\boldsymbol{E}(\boldsymbol{x}) - g_{moon}\hat{\boldsymbol{z}}$$

applying electric field data from plasma simulations

Tentatively, we use $v_0 = +1$ m/s. (need to improve a model for dust lift-off)

2. Time variation of dust charge (using plasma current densities modeled based on OML theory)

$$\frac{dq_d}{dt} = I_{ph}(\phi) - I_{phc}(\phi) - I_{swe}(\phi) + I_{swi}(\phi)$$

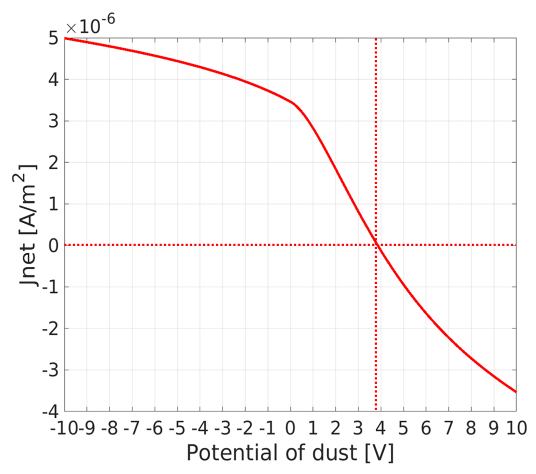
PE emission, PE collection, SW-e collection, SW-p collection

applying current field data from plasma simulations

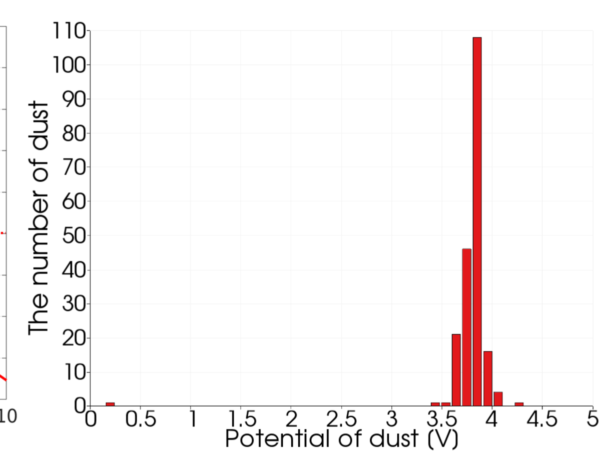
Dust charging in hole

In sunlight

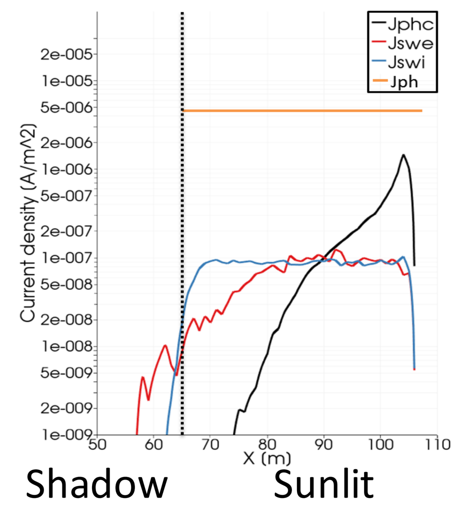
Current-voltage curve



Dust charge distribution



Plasma current mag. on dust grains in hole



Conclusions and outlook

- Unique electric & dust environment near **lunar vertical holes**, resulting from sunlit-shadow (SS) boundary

Differential charging

Intense E-field

Dust motion crossing the sunlit-sunless boundary

Outlook:

Reconsideration of dust charging model on lunar ground [e.g., Wang+ 2016]

Dust-plasma / dust-dust interactions depending on dust density