DRILLING IN A LUNAR POLAR CRATER

Grounding and triboelectric charge regulation in permanent shadow

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Lunar polar crater environment lacks electrical grounding

- Permanently shadowed polar craters - a potential water source - are predicted to exhibit poor electrical grounding conditions in the face of tribo-charging. [1]
- In the present study, we extend a recent plasma model [2] to examine tribo-charge accumulation on a drill.
- In addition, we characterize two photo-emission based grounding methods;
  1. Sun-facing conducting surface - outside the crater.
  2. UV lamp - at the drill site.

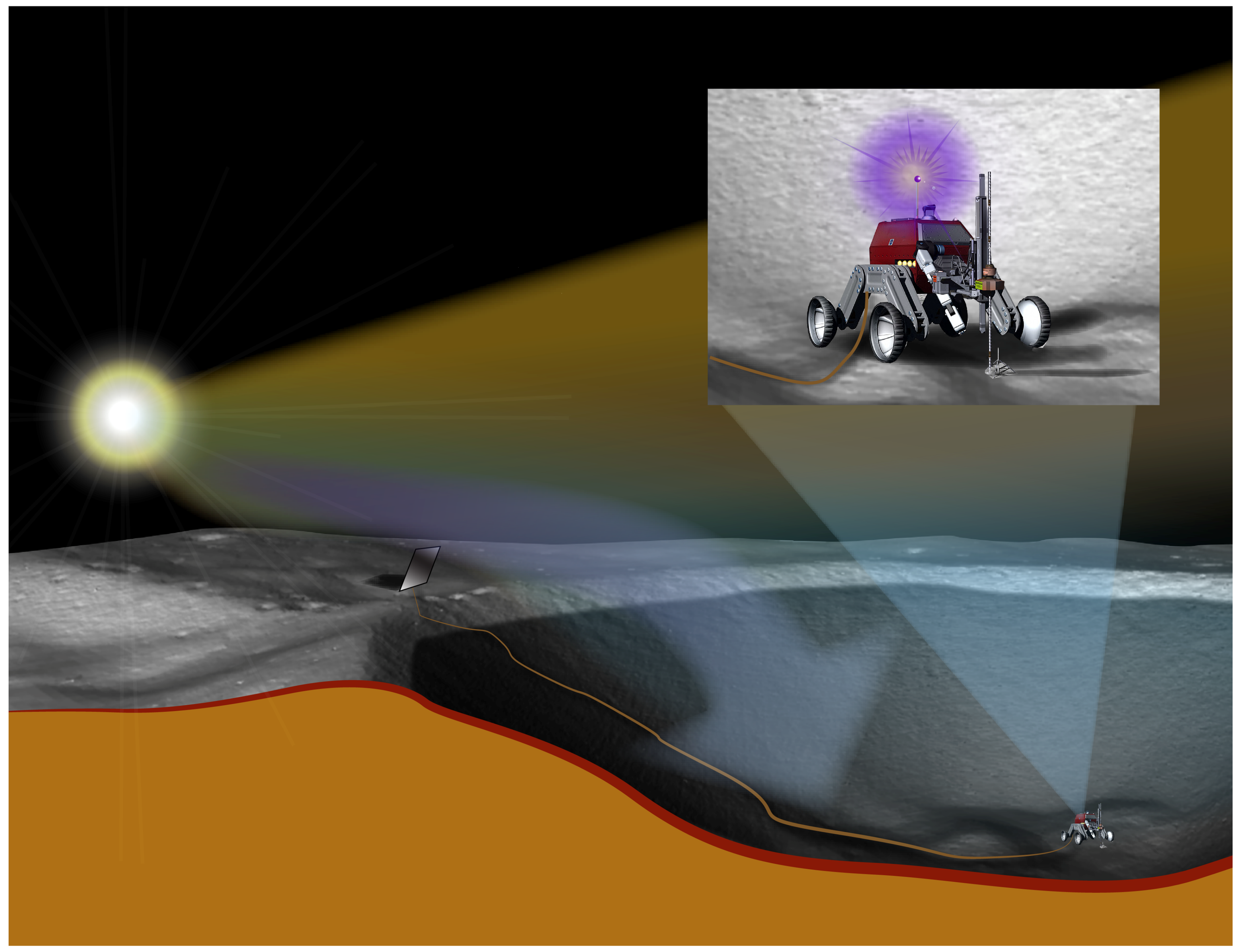

Fig. 1: A drill in the Moon's permanently shadowed Shackleton Crater, grounded to a sun-facing conducting surface. (*Image by Jay Friedlander, NASA GSFC*)

With Honeybee Robotics specs of $500cm^3$ regolith per hour [3], and assuming typical $70\mu m$ grains that saturate based on surface area, we estimate a tribo-charge current on the order of $\sim -1\mu A$.

Drill tribo-charge and grounding calculations

Plasma potential (Fig. 2 - left): The solar wind flow over a lunar crater creates a non-neutral region known as the *electron cloud*, resulting in a growing negative electrostatic potential. Without additional current, the far edge of the crater maintains a negligible floating potential.

Tribocharging (Fig. 2 - right): The addition of a small tribo-electric current source ($-0.8\mu A$) results in a large electrostatic potential, both in the electron cloud (dashed blue) and the far edge (dashed green).

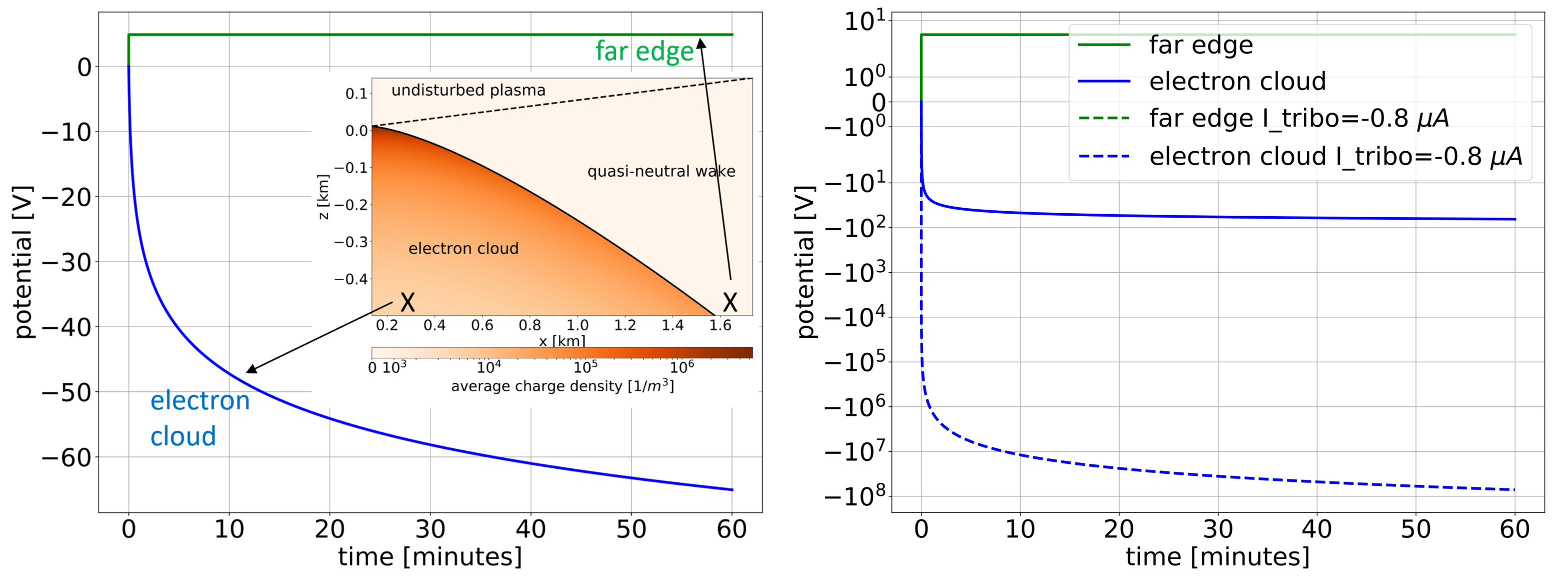

Fig. 2: Pre-tribocharging (left) and tribocharging (right) electrostatic potential in the electron cloud (blue) and far edge of the crater (green).

Grounding (Fig. 3): Given a tribo-charging current, we compute the required grounding for two equivalent solutions; (i) sun-facing conducting surface outside the crater or (ii) UV-lamp at the drill site. The results appear largely independent of the location within the crater.

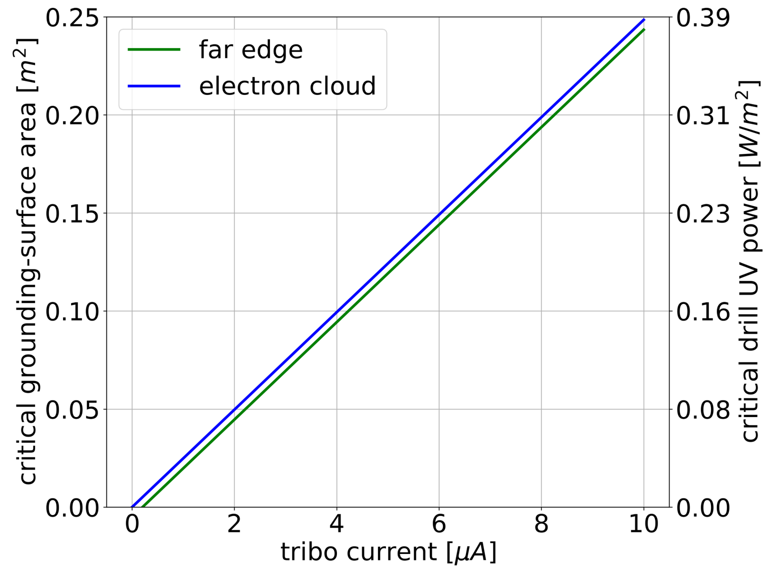

Fig. 3: The grounding surface area or equivalent UV-lamp illumination required for a tribo-charge current.

Next: NASCAP-2K 3D simulations

Successful benchmarking of NASCAP-2K simulations with analytic computation is shown in Fig. 4.

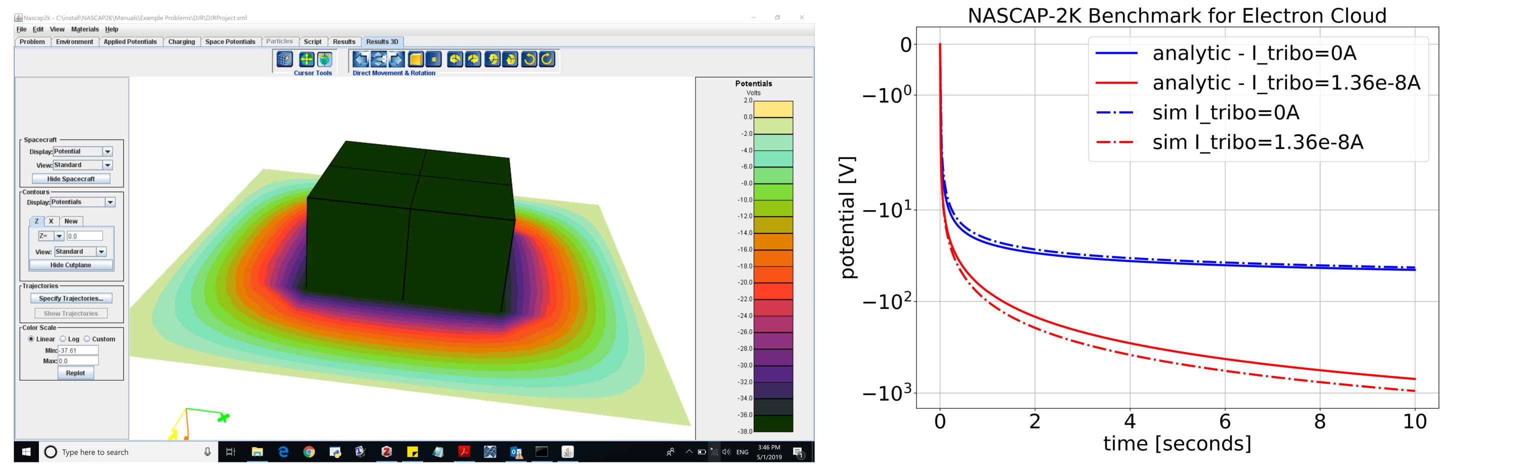

Fig. 4: Benchmarking simulations of a tribo-charging cube in the electron cloud.

Next Phase: Simulations with realistic 3D CAD models of exploration equipment in the lunar crater plasma environment.

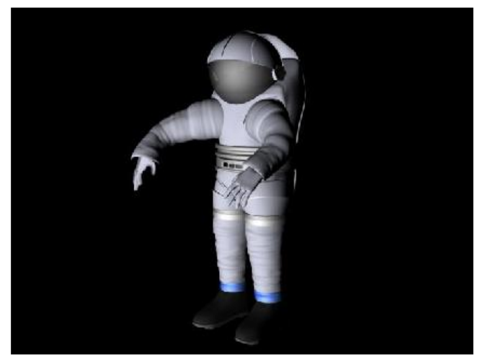

Fig. 5: 3D CAD model of space suit.

Advertisement: We welcome collaborators interested in equipment design for lunar exploration.

References

[1] Jackson et. al. (2015), *Rover wheel charging on the lunar surface*, Advances in Space Research.

[2] Rhodes and Farrell (2019), *Steady-state solution of a solar-wind generated electron cloud in a lunar crater*, JGR.

[3] Zacny et. al., Honeybee Robotics (2012) *LunarVader: Testing of a 1 meter lunar drill in a 3.5 meter vacuum chamber and in the Antarctic lunar analog site*, IEEE Aerospace Conference.

Acknowledgments

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