Modeling the lunar-polar-crater plasma environment

How solar-wind wakes affect volatile distributions and electrical grounding

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Why the interest in solar-wind plasma wakes?

1. SCIENCE: The resulting proton trajectory affects the distribution of volatile materials through surface sputtering. [1]

2. EXPLORATION: The resulting electron cloud defines the dissipation/buildup of static charge on rovers or astronaut equipment. [2]

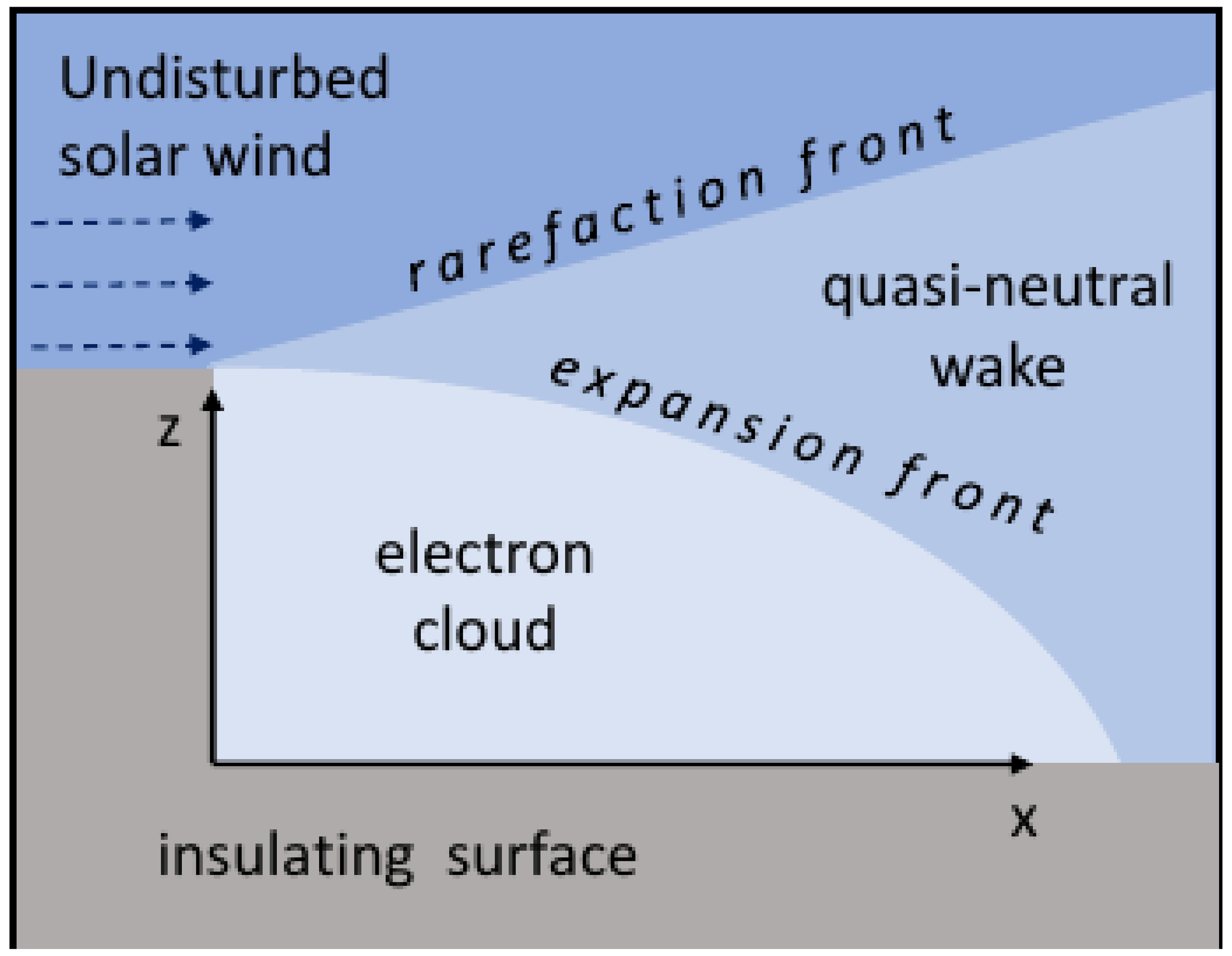

Fig. 1: The solar wind plasma wake in a lunar polar crater.

New analytic model rapidly characterizes near-surface plasma behavior

- Plasma expansion theory historically focused on ion acceleration (e.g. inertial fusion).
- Present model extends into the *electron cloud* [3], capturing additional surface physics that has been simulated [2] but is not fully understood.
- New analytic model matches two solutions:
  1. Quasi-neutral plasma; self-similar expansion.
  2. Maxwellian electron cloud; Bounded Poisson equilibrium.

Results of new model predict a unique plasma environment

The resulting spatial distribution and vertical contribution to the speed of ions striking the surface affects sputtering of volatile materials.

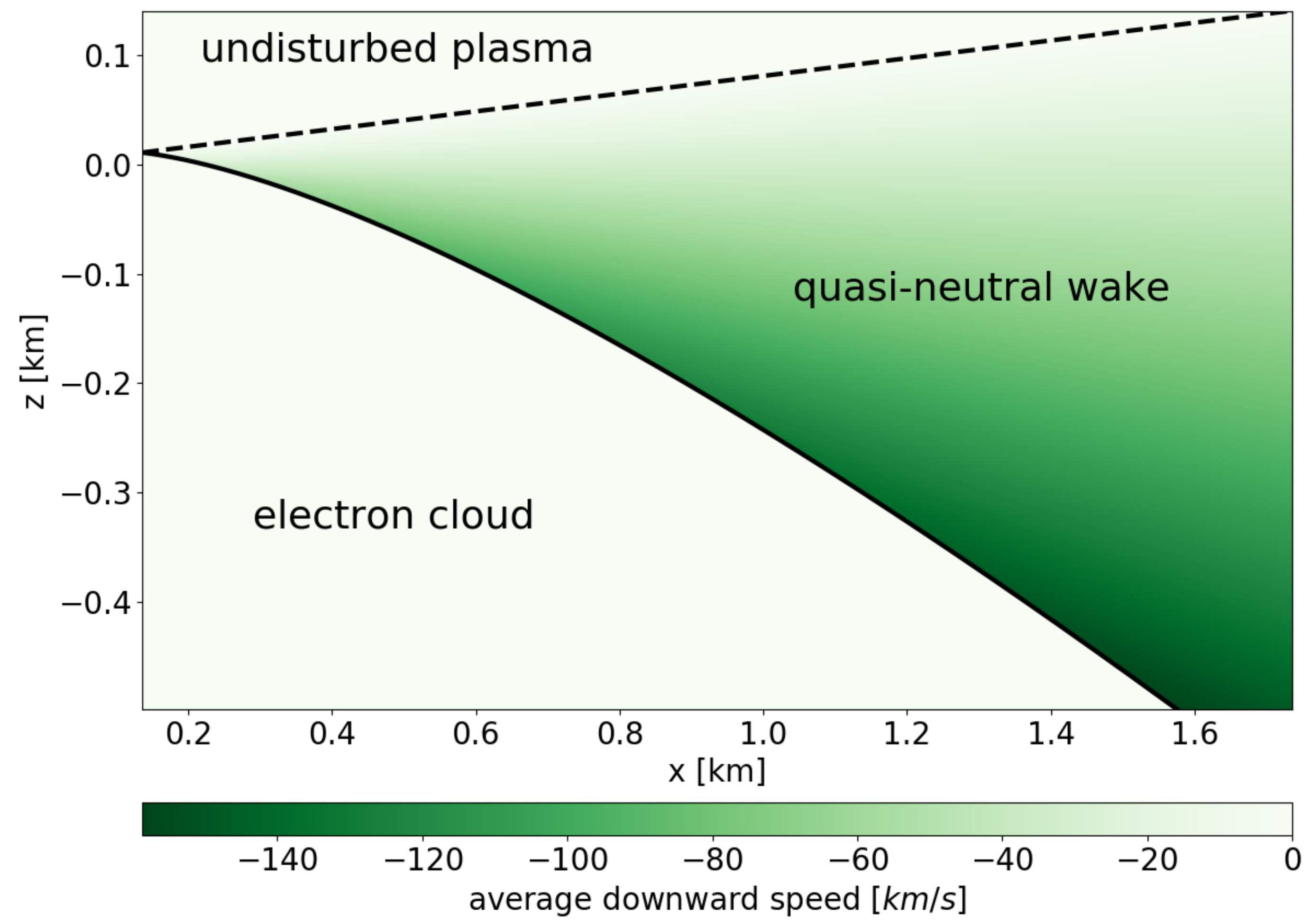

Fig. 2: Ion speed determines surface sputtering.

The electrostatic potential (w.r.t. undisturbed plasma) is successfully extended below the expansion front:

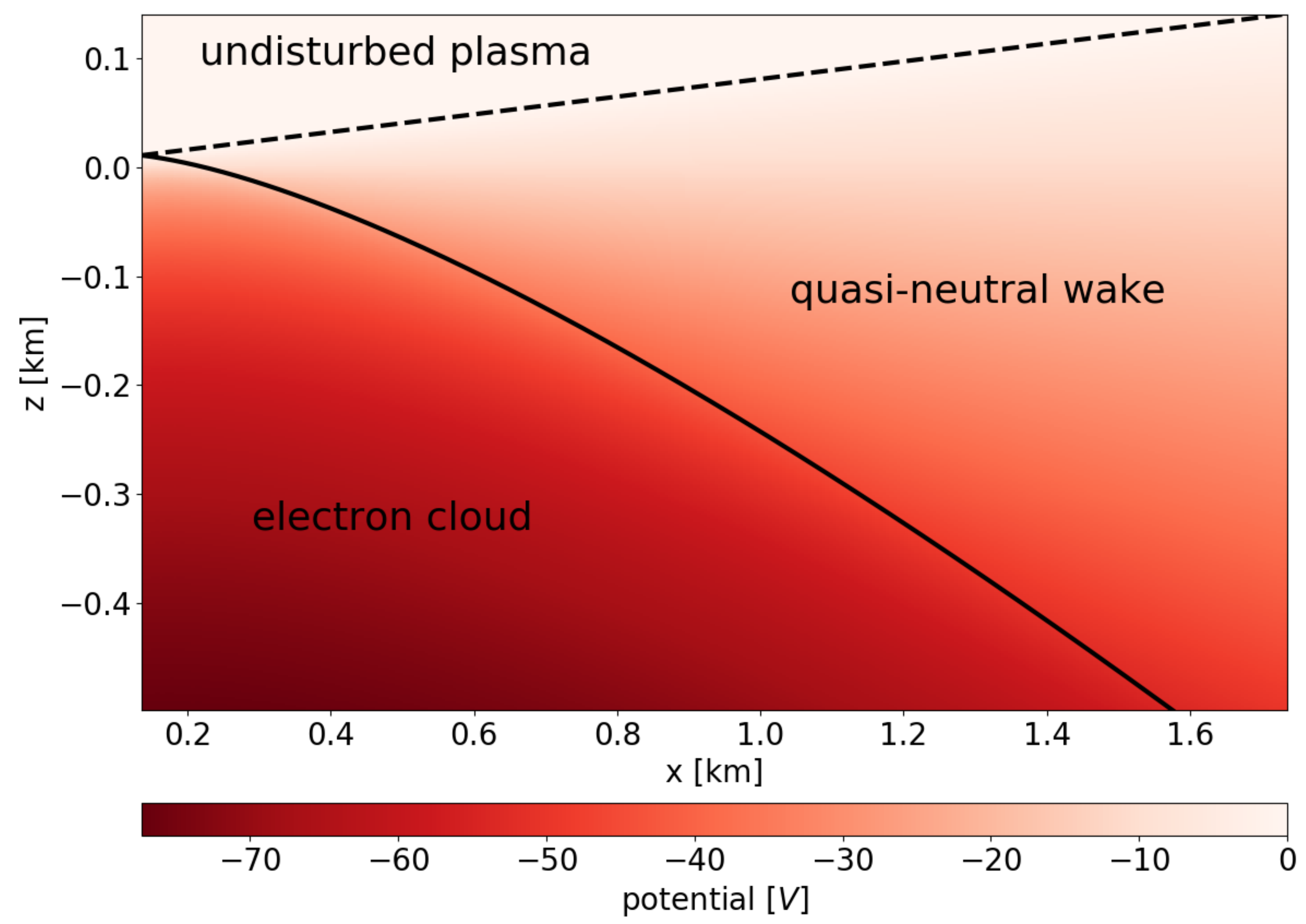

Fig. 3: Electrostatic potential introduces surface charge.

The resulting electron density characterizes the elecrical grounding for explorers on the crater surface:

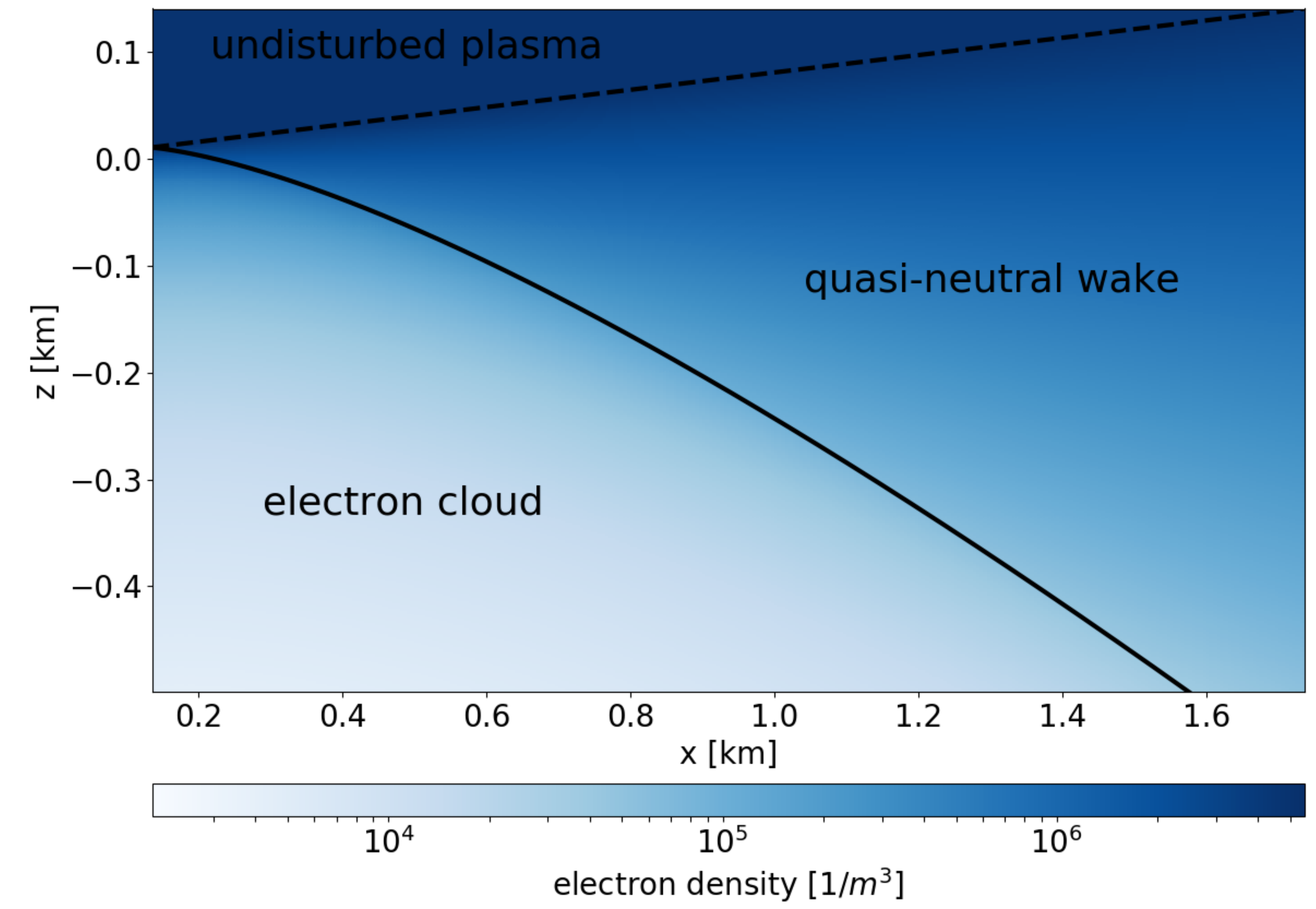

Fig. 4: Electron density characterizes dissipation/buildup of static charge on exploration equipment.

Next Steps

1. Benchmark with simulation (in progress).
2. Explore rich new physics: Non-Maxwellian (κ) distributions, supra-thermal surface charging, secondary electrons, dust lofting.
3. Simulate effects on exploration equipment.

References

[1] Farrell et. al. (2010), *Anticipated electrical environment within permanently shadowed lunar craters*, JGR.

[2] Zimmerman et. al. (2012), *Plasma wake simulations and object charging in a shadowed lunar crater during a solar storm*, JGR.

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

Acknowledgments

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