Modeling Lunar Dust Behavior to Advance the Effectiveness of Dust Mitigation Techniques

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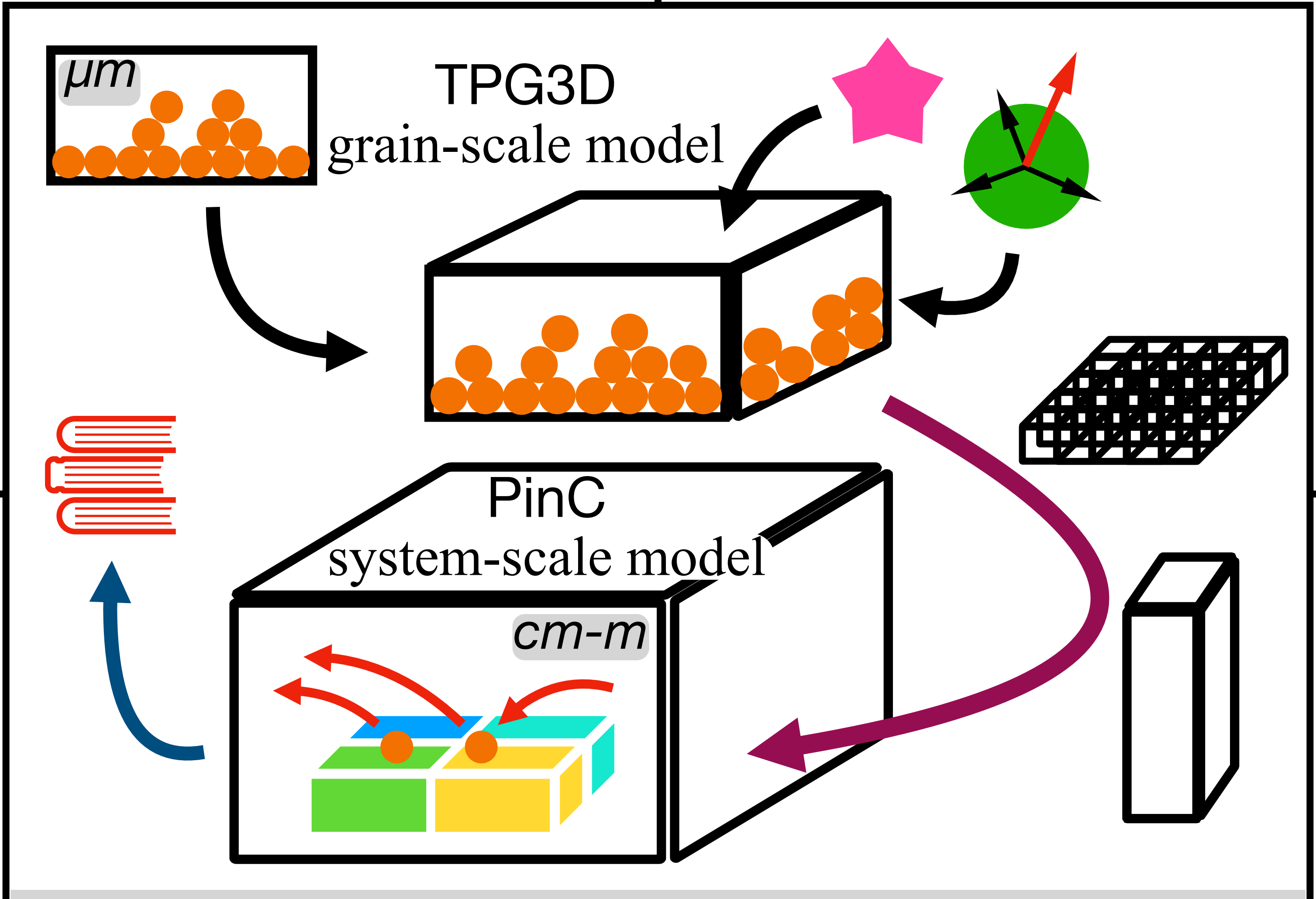
Objectives

- Develop a framework of numerical models that couple the microphysics of grain-scaled processes with the self-consistent solution of the near-surface plasma environment.
- Integrate existing numerical approaches to couple 7 orders of magnitude in time and space into a single, interwoven framework.
- Advance the current TRL=2 of both numerical models, basic algorithms, concepts, and coding.
- Reach TRL=4 by the end of the proposed project by completing the comprehensive physical models and confidently simulate complex charging, lofting, and dust transport processes that are relevant to environments expected in a variety of operational scenarios on the lunar surface.



Coupling regolith microphysics and lunar dust transport.

Approach

- We equip a basic test-particle (TPG3D) and particle-in-cell code (PinC) with a comprehensive multi-physics model and the necessary code-coupling mechanisms.

TPG2D → TPG3D

- Parallelize and extend to include irregular-shaped dust particles.
- Develop a force-balance model, including cohesion, adhesion, and microgravity effects.

PinC

- Expand the model to include multiple and composite surfaces.
- Develop a dust-kinetic model to describe dust transport phenomena.

Code coupling

- Develop the code structure to load TPG3D regolith surfaces into PinC.

Impact

- The proposed state-of-the-art numerical framework provides the simulation capabilities to better understand lunar dust particle cohesion, dust-to-surface adhesion, and dust transport phenomena in a variety of operational scenarios.
- Coupling TPG3D and PinC will results in better understanding the role that the micro-cavities forming between individual regolith particles have on dust charging, mobilization, and transport.
- The proposed framework will be used to merge the qualitative understanding of the microscopic processes to the macroscopic behavior of the lunar regolith, providing a much needed tool to advance the effectiveness of dust mitigation techniques. The predictive capability of this approach will be verified using existing laboratory experimental setups.