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Opportunity Title: Fundamental studies of cratering and ejecta dispersal on planetary bodies due to plume/granular-soil interaction
Opportunity Reference Code: 0214-NPP-NOV23-JPL-AeroEng

Organization National Aeronautics and Space Administration (NASA)

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Application Deadline 11/1/2023 6:00:59 PM Eastern Time Zone

Description During precision landing on a planetary body, supersonic plumes from positioning rockets impact the soil or regolith of the planetary body. The plume deforms the soil and forms one or multiple craters; in this process particles from the soil acquire momentum and become dispersed. If the thus displaced particles acquire sufficient momentum, they can disperse to large distances and may even impact nearby structures at very high speeds, thereby having the potential to cause significant destruction. This problem has already been recognized in the early days of the Apollo program of the 1960s. As reported by astronauts Conrad in Apollo 12 and Scott in Apollo 15 when landing, the lunar regolith rose to an altitude as high as 100 m and 50 m, respectively. These particles also caused haziness, obstructing the view of the astronauts during landing. In some applications, the particles may damage the coating of the lander antenna thereby changing the thermal properties of the antenna, thus impeding transmission of information from the lander to Earth. In other applications in which there is search for extraterrestrial life, it is important to know the depth of gas penetration from the plume, so that the search for life is not conducted within that range of penetration. Thus, elucidating the parameters controlling cratering and ejecta has high priority for NASA. As of now, JPL is one of the members of a team studying this topic for the forthcoming NASA Artemis mission under a Grand Challenge program which focuses on developing models and conducting simulations addressing this topic.

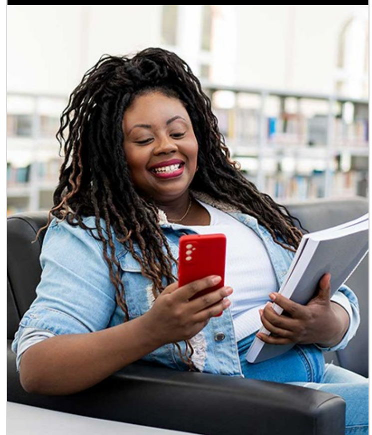
Our current research [1-4] uses fundamental concepts from fluid mechanics, Kinetic Theory, granular flow, transport-property theory, and rarefied-gas dynamics to construct a model describing the complex interaction between plume and soil. We performed three-dimensional Large Eddy Simulations (LESs) coupled with the granular flow equations and the results qualitatively reproduced crater photographs taken by the Mars Space Laboratory during landing on Mars [2]; we also explored cratering when potentially landing on Titan [3]. Our current emphasis is cratering when landing on Mars or on the Moon.

Experience with fluid dynamics modeling, LES coding and supercomputing is required; a solid background on Kinetic Theory and on multi-phase flows is desirable.

[1] J. Bellan, ""Large Eddy Simulation of supersonic round jets: effects of Reynolds and Mach numbers"", AIAA J., 54 (5), 1482-1498, 2016

[2] K. Balakrishnan and J. Bellan, “High-Fidelity Modeling and Numerical Simulation of Cratering Induced by the Interaction of a Supersonic Jet with Granular Soil"", International Journal of Multiphase Flow, 99(2), 1-29, 2018

[3] K. Balakrishnan and J. Bellan, “A Multi-Species Modeling Framework



for Describing Supersonic-Jet Induced Cratering in a Granular Bed: Cratering on Titan Case Study", International Journal of Multiphase Flow, 118, 205-241, 2019

[4] K. Balakrishnan and J. Bellan, "Fluid density effects in supersonic jet-induced cratering in a granular bed on a planetary body having an atmosphere in the continuum regime", under review, 2020

Location:
Jet Propulsion Laboratory
Pasadena, California

Field of Science: Aeronautics, Aeronautical or Other Engineering

Advisors:
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Applications with citizens from Designated Countries will not be accepted at this time, unless they are Legal Permanent Residents of the United States. A complete list of Designated Countries can be found at: https://www.nasa.gov/oiir/export-control.

Eligibility is currently open to:

- U.S. Citizens;
- U.S. Lawful Permanent Residents (LPR);
- Foreign Nationals eligible for an Exchange Visitor J-1 visa status; and,
- Applicants for LPR, asylees, or refugees in the U.S. at the time of application with 1) a valid EAD card and 2) I-485 or I-589 forms in pending status

Eligibility Requirements

- **Degree:** Doctoral Degree.