Utilization of ISS MISSE to assess regolith behaviour and corresponding small body impacts

Regolith is defined as the unconsolidated material which is loosely present on top of the planet's bedrock. This definition extends to asteroids, which are small rocky remnants of early Solar System and other planetary system formation processes. Until the early 2000s, it was believed that asteroids were all monolithic rocks with a bare surface. The NASA Galileo, NEAR Shoemaker mission showed conclusively, the presence of regolith on an asteroid's surface. Since then, many observations of other asteroids have shown that nearly all of them have a considerable regolith cover. As this quantity has not been studied well, it poses an issue for future exploratory missions.

Current experiments to study behaviour of this material are carried out in vacuum facilties with mechanical apparatus to simulate microgravity. Such experiments have been carried out at institutes such as ISAE-SUPAERO, MIT, Caltech et al. Owing to less regolith samples present on Earth due to the issue of lander reentry, these experiments are often carried out with quartz crystals as an analogue to regolith and glass beads to simulate lander characteristics. Microgravity is 'created' by Atwood machines, which do so by dropping the system from a height, essentially inducing freefall and weightlessness. Having studied these experiements, we found that the theoretical models built on this data to be extremely case-specific. An increase in any of the system characteristics, such as quartz crystal size, cause model breakdown. As such, they can't be relied upon to provide accurate outputs for actual landing missions.

The ISS has a long term project known as MISSE(Materials International Space Station Experiment). It is a series of externally mounted experiements that measure the performance, stability, and long-term survivability of materials and components. For automation of this process, several robots such as Canadarm2 are present. We propose that, this external environment should be used to measure regolith characteristics in a completely affordable and simpler manner in the relative safety of a LEO.

Regolith is formed by natural processes such as weathering, impact due to other bodies, and substratum geological movement. This leads to formation of granular particles. These are aggregated from the same material and have a distinct shape and size, differing from molecular crystals. On Earth, the **potential energy** of these granular particles would be larger than the specific **electrostatic energy** possessed. However, in space, this material behaves very differently. The electrostatic force suddenly becomes more dominant, causing a deviation from standard behaviour. Also, this granular material is a solid on Earth, but behaves as a fluid in space. Using the ISS ability to measure the **Froude number** is an important asset of characterizing its behaviour.

The proposed method solves several current issues for regolith testing:

1. No need of reentry for delivering actual regolith samples.
2. Actual conditions of asteroid operations.

3. Ideality of data can be extrapolated by including several test parameters, good generalization.
4. Fully automated data collection.

The recently conducted NASA DART mission included the impact of a small lander onto the asteroid Didymos which managed to increase the orbit time by 32 minutes, indicating that the change was significant. The upcoming ESA HERA mission is meant to study in detail this change in the asteroid orbit. Improvements in the understanding of surface geology could help future exploration missions and would also go a long way in perhaps, colonizing other planets.