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Microgravity Experiments from Sub-orbital to Orbital Platforms (3)

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ASTEX MICROGRAVITY EXPERIMENT: SIMULATING ASTEROID REGOLITHS

Abstract

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Despite their very low surface gravities, asteroids exhibit a number of different geological processes involving granular matter. Understanding the mechanical response of this granular material subject to external forces in microgravity conditions is vital to the design of a successful asteroid sub-surface sampling mechanism, and in the interpretation of the fascinating geology on an asteroid.

To date there have been two space missions sent to characterise an asteroid in detail: the NEAR Shoemaker mission to (433) Eros, and the Hayabusa sample return mission to (25143) Itokawa. NEAR revealed a substantial regolith covering Eros [1], and Hayabusa revealed Itokawa to be a rubble pile asteroid (essentially made of regolith throughout) [2]. A dichotomy of rough and smooth surfaces was also observed at Itokawa including evidence of varied particle size and grain size sorting.

The state of a granular system is characterized by density, granular temperature and pressure. Recent research has shown that the direction of prior shear influences how granular matter starts to flow [3]. Due to the increased importance of inter-particle dynamics in a microgravity environment typical at an asteroid surface, the regolith may respond differently to analogous regolith on Earth. Therefore a sampling mechanism designed to work in a 1g environment on Earth may not necessarily work in a lower gravity environment such as the microgravity environment encountered at an asteroid.

The AstEx experiment, entitled 'Simulating Asteroidal Regoliths: Implications for Geology and Sample Return', will investigate the dynamics of regolith on asteroid surfaces. The experiment uses a microgravity modified Taylor-Couette shear cell to investigate granular flow caused by shear forces under the conditions of parabolic flight microgravity. It will determine how a steady state granular flow is achieved in microgravity conditions, and what effect prior shear history has on the timescales involved in initiating a steady state flow in a granular material.

This paper presents the technical details of the AstEx experimental design with particular emphasis on how the team have designed the equipment specifically for the microgravity environment. Several key

design issues are discussed such as the removable cartridge based shear cell concept for easy repetition. Additionally, small gravity fluctuations exist during the weightless period of a parabolic flight of magnitude 0.05g. A solution is presented for removing this negative gravity to avoid potentially resetting the grain contact network.

The AstEx experiment has been selected through ESA's 'Fly your Thesis' program to fly as part of the ESA 51st Microgravity Research Campaign in November 2009.

References

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