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IMPACTS OF FREE-FLOATING OBJECTS: UNIQUE SPACE STATION EXPERIMENTS

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The transfer of momentum and kinetic energy between planetary bodies forms the basis for wide-ranging problems in planetary science ranging from the collective long-term effects of minor perturbations to the catastrophic singular effect of a major collision. In the former case, we can cite the evolution of asteroid spin rates and orientations (1,2,3,4)) and planetary rotation rates (5). In the latter case, we include the catastrophic disruption of asteroids (3,6,), sudden but lasting changes in planetary angular momenta (7,8), and the near-global disruption of partially molten planets (9,10). Although the collisional transfer of momentum and energy has been discussed over the last two decades, major issues remain that largely reflect current limitations in earth-based experimental conditions and 3-D numerical codes. Two examples with potential applications in a Space Station laboratory, are presented below.

Asteroid Spin Rates and Orientations: Understanding the transfer of impactor translational momentum to target angular momentum is fundamental to understanding the present-day spin rates, orientations, and spin-limited disruption of asteroids (e.g., see 3). The efficiency of angular momentum transfer is typically expressed as a factor (ζ) ranging from 0 for purely elastic collisions to 1 for inelastic collisions with no ejecta loss (3). Although ζ is usually adopted as unity, Harris (4) prefers a value closer to 0.5 corresponding to a moderate forward-scattering of ejecta. Davis *et al.*, (3) suggest that ejecta are uniformly distributed -- even for low-angle impacts; consequently values of ζ closer to 1 might be justified. Such estimates, however, are largely based on intuition. For vertical impacts into basalt, ejecta carry away 4-6 times the original impactor momentum; therefore, the azimuthal distribution of these ejecta is crucial. For very low-angle impacts, the impactor is ricocheted down-range and carries with it considerable momentum (11). These results would indicate a value of ζ significantly less than 1. Even lower values may occur for curved surfaces. Recent experiments in easily volatilized material (12) reveal significant differences in the partition of energy at low-impact angles. Such differences might lead to differences in impact-induced spin rates between comets and asteroids (13).

Thus a wide range of values in ζ that depend on impact velocity and target composition/strength can be justified. Experiments are needed wherein free-floating non-spinning and spinning objects of varying strength, porosity, volatility, and strength are impacted at varying impact velocities and angles. A Space Station provides a unique and ideal environment for performing such experiments.

Planetary Disruption/Spin-Rates: The existing rotation periods and total angular momenta of gravitationally bound planets and planet-satellite systems may provide a fundamental link between the accretion and post-accretion stages of planetary evolution. The Moon and Mercury preserve a record of impacts of sufficient energy to produce possible antipodal disruption of the surface as indicated by observations and simplified calculations (9). More sophisticated 2-D axisymmetric finite-element codes reveal that a molten interior enhances disruption.

Taken to extreme, a collision-vaporization model of the Earth-Moon system has been recently revived with vigor and substance (14,15). Although preliminary calculations have been made to describe the impact-induced vaporization of the early terrestrial crust and the transfer of angular momentum (16), such models are limited by necessary simplifying assumptions including 1-D and 2-D descriptions of a 3-D event. It is unlikely (albeit fortunate) that a directly scaled event will occur. A space station platform, however, provides a unique opportunity to test important facets of such models by allowing freely suspended spherical targets of varying viscosities, internal density gradients, and spin rates. Although a centralized gravity term cannot be introduced or completely simulated, such limitations are far outweighed by variables that can be readily introduced and controlled.

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