Accelerator Technologies for Simulation of Dust Impacts at Starflight Velocities

Andrew J. Higgins[1]*
[1] McGill University, Montreal, Quebec, CANADA H3A 0C3

Abstract

The problem of the impact of dust grains on spacecraft traveling at velocities required for interstellar travel ($v \sim 0.1\ c$) has been treated by only a handful of studies. [1-4] Considerable uncertainty in the physics of impacts and how the energy dissipated in the impact couples to the rest of the structure of the spacecraft exists, and it is likely that laboratory experimentation is required for validation of the computational simulation of such impacts. This paper will review existing technologies capable of accelerating macroscopic objects (i.e., impactors representative of dust grains) to ultrahigh velocities, highlighting the "no man's land" that exists in particle mass and velocity space between launchers used in hypervelocity impacts (light gas guns, shaped-charge accelerators, electrostatic dust accelerators, electromagnetic launchers, etc.) and accelerators for fundamental particles (linacs, cyclotrons, etc.). The physics-based limitations responsible for this gap will be identified, namely (*i*) field-emission limits on electric field gradients for electrostatic launchers and (*ii*) ultrahigh current switching limitations on electromagnetic launchers. The history of the development of accelerators for impact fusion applications, likely the closest application in terms of particle mass/velocity requirements for the present problem, will be briefly reviewed. [5] Some promising—but previously unrecognized—approaches that might be able to access the particle size/velocity region of interest will be identified, such as macromolecular ion accelerators developed for mass spectrometry of biomolecules. [6] Ongoing experimental research at the author's laboratory at McGill University to push shaped-charge accelerators capable of launching small pellets of condensed matter into the 10^4-10^6 m/s velocity regime will also be presented. [7]

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Keywords: Accelerator Technology, Hypervelocity, Ultravelocity, Impact Physics

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*Corresponding author, andrew.higgins@mcgill.ca