ULTRA-FAST COLLISIONAL ION HEATING BY ELECTROSTATIC SHOCKS

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Radiation pressure, provided by a high intensity laser, has previously been used to drive electrostatic shocks to accelerate bunches of ~10^9 ions to ~MeV energies [1, 2, 3, 4, 5].

We describe a new effect of radiation pressure driven electrostatic shocks; the bulk heating of ions to temperatures on the order of keV in near-solid density targets over time scales of tens of femto-seconds by ion-ion collisions. Unlike ion heating by conventional shocks, this heating is driven by dynamical friction between ion species of different charge-to-mass ratios during their acceleration by the electric field associated with the shock, and by a local density increase caused by the passage of the electrostatic shock. In contrast to ion acceleration by electrostatic shocks, in which a small fraction of the ion population gain large kinetic energies in the laboratory frame, this mechanism heats the entire ion population in the frame of the ions. The phenomenon is explored through PIC (particle-in-cell) simulations of high intensity (> 10^{18} W/cm^2), short pulse (< 100 fs) lasers incident on solid density targets.

[1] D. Forslund and C. Shonk, “Formation and Structure of Electrostatic Collisionless Shocks," *Physical Review Letters*, vol. 25, pp. 1699-1702, Dec. 1970.

[2] L. O. Silva, M. Marti, J. R. Davies, and R. A. Fonseca, “Proton Shock Acceleration in Laser-Plasma Interactions," *Physical Review Letters*, vol. 92, p. 015002, Jan. 2004.

[3] A. Macchi, F. Cattani, T. Liseykina, and F. Cornolti, “Laser acceleration of ion bunches at the front surface of overdense plasmas," *Physical Review Letters*, vol. 165003, no. April, pp. 2-5, 2005.

[4] C. A. J. Palmer, N. P. Dover, I. Pogorelsky, M. Babzien, G. I. Dudnikova, M. Ispiriyan, M. N. Polyanskiy, J. Schreiber, P. Shkolnikov, V. Yakimenko, and Z. Najmudin, “Monoenergetic proton beams accelerated by a radiation pressure driven shock," *Physical Review Letters*, vol. 106, p. 014801, Jan 2011.

[5] F. Fiuza, A. Stockem, E. Boella, R. a. Fonseca, L. O. Silva, D. Haberberger, S. Tochitsky, C. Gong, W. B. Mori, and C. Joshi, “Laser-Driven Shock Acceleration of Monoenergetic Ion Beams," *Physical Review Letters*, vol. 109, p. 215001, Nov. 2012.