DPP12-2012-001055

Abstract for an Invited Paper
for the DPP12 Meeting of
the American Physical Society

Excitation of Transverse Dipole and Quadrupole Modes in a Pure Ion Plasma in a Linear Paul Trap to Study Collective Processes in Intense Beams[1]

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Transverse dipole and quadrupole modes have been excited in a one-component cesium ion plasma trapped in the Paul Trap Simulator Experiment (PTSX) in order to characterize their properties, and understand the effect of their excitation on equivalent long-distance beam propagation. The PTSX device is a compact laboratory Paul trap that simulates the transverse dynamics of a long, intense charge bunch propagating through an alternating-gradient transport system by putting the physicist in the beam's frame of reference. A pair of arbitrary function generators was used to apply trapping voltage waveform perturbations with a range of frequencies and, by changing which electrodes were driven with the perturbation, with either a dipole or quadrupole spatial structure. The results presented in this paper explore the dependence of the perturbation voltage's effect on the amount of trapped charge, the perturbation duration and amplitude. Perturbations were also applied that simulate the effect of random lattice errors that exist in an accelerator with quadrupole magnets that are misaligned or have variance in their field strength. The experimental results quantify the growth in the equivalent transverse beam emittance that occurs due to the applied noise and demonstrate that the random lattice errors interact with the trapped plasma through the plasma's internal collective modes. Coherent periodic perturbations were applied to simulate the effects of magnet errors in circular machines such as storage rings. The trapped one component plasma is strongly affected when the perturbation frequency is commensurate with a plasma mode frequency. The experimental results, which help to understand the physics of quiescent intense beam propagation over large distances, are compared with analytic models and particle-in-cell simulations.

[1]This research is supported by the U.S. Department of Energy.