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Radio-Frequency and Magnetic Trap Simulations of Beam Propagation over Long Paths

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H. Okamoto, M. Endo, K. Fukushima, H. Higaki, K. Ito, K. Moriya, and S. Yamagichi

Graduate School of Advanced Sciences of Matter, Hiroshima University, 1-3-1 Kagamiyama, Higashi-Hiroshima 739-8530, Japan

An overview is given of the novel beam-dynamics experiments based on tabletop non-neutral plasma traps at Hiroshima University. We have designed and constructed two different types of trap systems, one of which uses a radio-frequency electric field (Paul trap) and the other uses an axial magnetic field (Penning-Malmberg trap) for transverse plasma confinement. These systems are called "S-POD (Simulator for Particle Orbit Dynamics)". S-POD can approximately reproduce the collective motion of a charged-particle beam propagating through long alternating-gradient (AG) focusing channels, thus enabling us to study various beam-dynamics issues without relying on large-scale accelerators.

So far the linear Paul traps have been applied for the study of resonance-related issues including coherent stop-band excitation and its dependence on AG lattice structures, resonance crossing in fixed-field AG accelerators, ultralow-emittance beam stability, etc. We have often made use of 40Ar+ plasmas for Paul trap simulations while 40Ca+ ions coolable with compact semi-conductor lasers are occasionally chosen for ultracold beam experiments. The dimension of the traps is smaller than about 20 cm and the operating frequency of the current systems is in the range of 1 −2 MHz. The typical lifetime of an ion plasma, even without pre-conditioning by buffer-gas or Doppler cooling, exceeds a few seconds corresponding to millions of FODO cells. On the other hand, the Penning-Malmberg trap with multi-ring electrodes has been applied mostly for the study of beam halo formation driven by initial disturbance. For this purpose, only pure electron plasmas have been employed, but we are now planning to confine heavy ions as well by increasing the magnetic field strength. In this paper, we briefly explain how S-POD works and then summarize recent experimental results on resonance effects and halo formation.

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Primary author: OKAMOTO, H. (Graduate School of Advanced Sciences of Matter)

Presenter: OKAMOTO, H. (Graduate School of Advanced Sciences of Matter)

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