Alexander Papash, J Astrophys Aerospace Technol 2017, 5:2 (Suppl)
DOI: 10.4172/2329-6542-C1-008

2nd International Conference on

ATOMIC AND NUCLEAR PHYSICS

November 08-09, 2017 | Las Vegas, USA

Long term beam dynamics and ion kinetics in ultra-low energy storage rings

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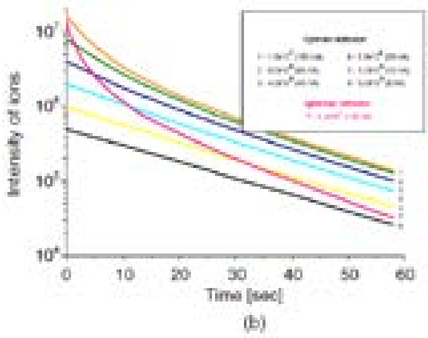
Electrostatic storage rings operate at very low energies in the keV range and have proven to be invaluable tools for atomic and molecular physics. Because of the mass independence of electric rigidity, these machines are able to store a wide range of different particles, from light ions to heavy singly charged bio-molecules, opening up unique research opportunities. However, earlier measurements have shown strong limitations on beam intensity, fast growth of beam size and decay of ion current, reduced lifetime of ion beam. The nature of these effects has not been fully understood. Also a large variety of experiments in future generation ultra-low energy storage and decelerator facilities including in-ring collision studies with a reaction microscope require a clear understanding of the physical processes involved into the operation of such rings. Nonlinear and long-term beam dynamics studies in ultra-low energy storage rings are presented on the examples of a number of existing and planned electrostatic storage ring facilities. The results from simulations were benchmarked against experimental data of beam losses in the ELISA storage ring [S.P. Møller et al., Proceed of the European Particle Accelerator Conference, Vienna, 2000, pp. 788–790)]. It was shown [1,2,3] that decay of beam intensity is mainly caused by ion losses on ring aperture due to multiple scattering on residual gas. Beam is lost on electrostatic elements and collimators due to small ring acceptance. Rate of beam losses increases at high intensities because of the intra-beam scattering effect adds to vacuum losses. Detailed investigations into ion kinetics, under consideration of effects from electron cooling and multiple scattering of the beam on a supersonic gas jet targets, were carried out and yields a consistent explanation of the physical effects in a whole class of ultra-low energy storage rings. The lifetime, equilibrium momentum spread, and equilibrium lateral spread during collisions with the target are estimated. Based on computer simulations, the conditions for stable ring operation with an extremely low-emittance beam are predicted. Finally, results from studies into the interaction of ultra-low energy ions with a gas jet target are summarized.



Computer simulations of O- ions decay in ELISA ring at 22 keV beam energy.

Biography

Alexander Papash is a Research Scientist (PhD) and he is expert in Accelerator Physics. He was graduated from the Physical Department of Kiev State University (Ukraine). He has more than 30 years of research and engineering experience in design and operation of scientific and commercial accelerators worldwide, namely, at Karlsruhe Institute of Technology and Max-Planck Institute of Nuclear Physics (Heidelberg, Germany), Joint Institute for Nuclear Research (Dubna, Russia), Kiev Institute for Nuclear Research (Ukraine), Canadian National Meson Facility TRIUMF (Vancouver) and Laboratorio Nucleare del Sud (Catania, Italy).

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