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## Beam dynamics 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. It was shown 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 target, were carried out and yielded 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.

### Recent Publications

1. A I Papash, A V Smirnov and C P Welsch (2014) Beam dynamics in an ultra-low energy storage rings (Review of Existing Facilities and Feasibility Studies for Future Experiments). *Physics of Particles and Nuclei* 45(2): 409–451.
2. A I Papash, A V Smirnov and C P Welsch (2013) Nonlinear and long-term beam dynamics in low energy storage rings. *Phys. Rev. St Accel. Beams* 16(6):1-21.

### Biography

Alexander Papash has his expertise in Accelerator Physics. He has more than 30 years of research and engineering experience in design and operation with scientific and commercial accelerator facilities worldwide, including investigations of non-linear effects and ion kinetics in ultra-low energy storage rings, beam dynamics studies in electron synchrotrons and cyclotrons. He proposed consistent explanation of high beam loss rates, fast growth of momentum spread and beam size in an ultra-low energy rings. Computer simulations of non-linear effects in an electrostatic ion storage rings have been performed and beam tracking in 3D relaxation electric fields were done. Ion kinetics and long term beam dynamics including transition and equilibrium conditions in ultra-low energy rings have been investigated and benchmarked against experimental data. Some predictions on future experiment results are made. He is a Scientist currently working at Karlsruhe Institute of Technology, Germany.

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