Control of Longitudinal Dynamics of Non-Neutral Plasma in the PUMA Trap

TECHNISCHE UNIVERSITÄT DARMSTADT

Master thesis project
Physics/Electrical engineering
February 27, 2023

Description

The **antiProton Unstable Matter Annihilation** (PUMA) experiment is a new nuclear physics experiment at CERN which will provide the ratio of protons and neutrons in the nuclear density tail as a new observable to test nuclear structure theories[1]. To determine this ratio, the concept of antiprotonic atoms is used. As there is no joint facility for antiprotons and short-lived nuclei available, PUMA aims at storing **antiprotons in a transportable Penning-Malmberg trap** at the Antimatter Factory of CERN and bringing them to ISOLDE/CERN for studies with radioactive nuclei.

This leads to various requirements and challenges for the trap. The general objectives on the simulation side are to deepen the understanding of applied manipulation techniques and to provide fast predictive models with emphases on **stability and control of the plasma**, thereby facilitate the setup and adjustment of the experimental parameters.

This work aims to investigate the **longitudinal dynamics of multi-species non-neutral plasma** in Penning-Malmberg traps, esp. the **autoresonant excitation** that is used to control the energy of the ions in the nested potential of the PUMA collision trap.

Work plan

- Numerical integration of the Vlasov-Poisson system of equations in one dimension for arbitrary external potentials
- Investigate autoresonant excitation and conduct parameter studies
- Explore 3D corrections within CST or other field solvers.

Prerequisites

Interest in numerical methods and field simulation, solid knowledge of the basics of electrodynamics and physics, basic programming skills

Contact:
Luisa Riik, M.Sc.
luisa.riik@tu-darmstadt.de
Office: S2|17 240

Contact:
Prof. Dr. Oliver Boine-Frankenheim
boine-frankenheim@temf.tu-darmstadt.de
Office: S2|17 226

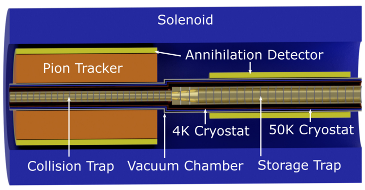

Figure 1: Sketch of the PUMA setup[1].

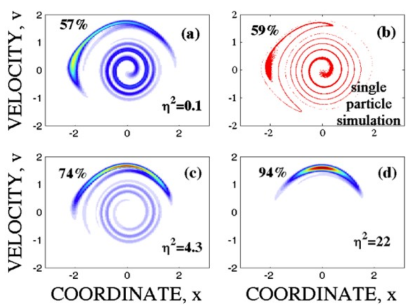

Figure 2: Phase space after passage through resonance for different plasma densities[2].

[1]Aumann, T., Bartmann, W., Boine-Frankenheim, O. et al. PUMA, antiProton unstable matter annihilation. Eur. Phys. J. A 58, 88 (2022)
[2]Barth, I., Friedland, L., Sarid, E. and Shagalov, A.G. Autoresonant Transition in the Presence of Noise and Self-Fields. PRL 103, 155001 (2009).