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Energy Loss of an Antiproton in an Electron Plasma

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In modern charged particle collider research, increasing the number of investigated events requires beams with high-quality characteristics, particularly high brightness and low velocity spread. This can be achieved using beam cooling techniques. The most well-known among them is electron cooling, which involves colliding fast charged particles with a cold electron beam, resulting in a reduction in the velocity spread of the particles [1]. Despite its widespread use in accelerator technology, several theoretical issues related to this method remain unresolved. These include the dependence of energy loss on the particle's charge sign, the electron beam temperature, its velocity distribution, and other factors. These problems still lack a comprehensive theoretical description. For example, explaining the energy loss difference between protons and antiprotons within binary collision theory requires a phenomenological approach with additional adjustable parameters. Notably, the cooling difference between protons and antiprotons is relevant to the FAIR (Facility for Antiproton and Ion Research) project at GSI in Darmstadt, where advanced physics experiments with antiprotons and heavy ions will be conducted [2].

This work studies the deceleration of a charged particle in an electron plasma using a nonlinear dielectric model and one-dimensional Particle-In-Cell (1D PIC) simulations, taking into account close collisions between the external charged particle and electrons. The one-dimensional model is justified by the magnetization of electrons in electron cooling. The simulation parameters were as follows: the thermal velocity of electrons was taken as the unit of velocity, the inverse plasma frequency as the unit of time, and the Debye radius as the unit of length. The length of the simulation domain was L=1000, with 2000 cells, a time step of 0.1, and 10 particles per cell. Periodic boundary conditions were applied.

The simulations yielded time-dependent energy profiles for oppositely charged particles at various values of the velocity of the external particle. It was shown that for fast particles, the obtained dependencies agree well with analytical expressions. However, at five thermal velocities, a significant deviation was observed. A comparison of energy losses showed no significant deceleration difference at high velocities due to collective effects. However, for intermediate cases, a difference is observed, analogous to the Barkas effect. Close collisions between the external particle and plasma electrons were also taken into account using the Monte Carlo method. It was assumed that negatively charged ions reflect electrons forward and backward along the magnetic field if they are located at small impact parameters, while protons, on the contrary, attract electrons, causing them to accelerate and pass close to the proton without energy transfer. These simulations qualitatively demonstrate the possibility of energy loss differences between protons and antiprotons in an electron plasma.

References

[1] H. Poth, Electron cooling, Theory, Experiment, Application. Physics Reports. 1990, vol. 196, p. 135.
[2] B. Galnander et al., HESR Electron Cooler Design study. Technical report, The Svedberg Laboratory, Uppsala University, 2009.

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