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Tailored Positron Beams from Trapped Single-component Plasmas[1]

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There are a number of important uses of antiparticles (e.g., positrons and antiprotons) including the creation of antihydrogen, modeling astrophysical processes, and the characterization of materials and material surfaces. Much of this progress has been driven by the development of new plasma techniques to accumulate, manipulate and store antiparticles. This talk focuses on recent work[2,3] to create specially tailored positron beams with small transverse spatial extent ρ_b, narrow energy spreads ΔE, and high brightness by pulsed extraction from plasmas in a Penning-Malmberg trap. Experiments are presented using electron plasmas for increased data rate. By briefly lowering the exit-gate potential, beam pulses ($\Delta t < 10$ μsec) from near the plasma center are created with $\rho_b = 2\lambda_D$ (HW $1/e$) and $\Delta E \approx T$, where λ_D is the plasma Debye length, and T is the plasma temperature. Specifically, by tailoring the plasma temperature to $T \approx 25$ meV and density to $n_0 \approx 10^{10}$ cm^{-3}, beams are created with $\Delta E < 35$ meV and $\rho_b < 50$ μm. A nonlinear model for beam extraction is used to derive expressions for the beam amplitude N_b, transverse spatial profile $\sigma_b(r)$, and single particle energy distribution as a function of the exit-gate potential V_E, trap wall radius R_W, and plasma parameters.[3] All predictions are verified for a wide range of plasmas. Protocols to optimize ρ_b and ΔE for various applications will be discussed. Prospects for cryogenic beams and pulsed extraction from the confining B field (to $B = 0$, for brightness enhancement and electrostatic focusing) will be discussed along with selected applications.

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[2]T. R. Weber, J. R. Danielson and C. M. Surko, Phys. Plasmas **15**, 012106 (2008).
[3]T. R. Weber, J. R. Danielson and C. M. Surko, Phys. Plasmas **16**, 057105 (2009).