Recent development of a multi-cell non-neutral plasma trap for A Positron Electron eXperiment (APEX)

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APEX aims to create the first magnetically confined positron-electron (pair) plasma to test the fundamentals of plasma theory. To this end, an unprecedented number of 10^{10} to 10^{11} cold positrons needs to be accumulated and transferred to the pair-plasma trap [1].

Positrons can be accumulated in Penning-Malmberg (PM) traps. In these traps, charge particles are confined radially due to a magnetic field and axially due to an electrostatic potential well. When large quantities of particles are accumulated a significant space charge builds up, which limits the capacity of those traps. To avoid large space charges, the multi-cell PM trap concept was developed. This device distributes the plasma space-charge into multiple storage traps that are arranged on and off axis, to fit into the same magnetic field [2]. Pulses of positrons are firstly captured in a large-diameter trap, right next to the storage traps. Subsequently, the positrons are transferred to the storage traps.

The present contribution describes the recent development of a multi-cell trap for APEX which has been characterized by use of electrons [3]. For the off-axis transfer the diocotron mode is excited to displace the electrons off axis. However, during the injection in the storage traps, a new kind of this mode occurs, the so-called competing diocotron motion [3]. This mode that can lead to a significant loss of particles. A technique is presented, which suppresses this mode and allows to transfer all initially captured particles to the off-axis storage traps. Figure 1 shows images of an electron plasma ejected onto a phosphor screen that demonstrate the mode control.

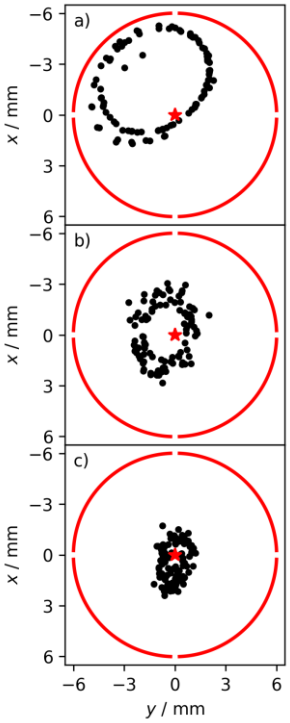

Figure 1: Boundaries of an off-axis storage trap (red) and the competing diocotron drift orbit of the plasma during the transfer (black dots). a) Motion without interference, which leads to charge loss. In b) the mode is centered in the storage trap, and in c) the amplitude of the orbit is reduced as a preparation for a lossless transfer.

[1] M.R. Stoneking, et al. *Journal of Plasma Physics* 86.6 (2020): 155860601.

[2] D.R. Wittemann, et al. *Journal of Plasma Physics* 89.4 (2023): 935890405.

[3] M. Singer, et al. *Journal of Plasma Physics* 89.5 (2023): 935890501.