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Characterization of pure electron plasmas in a levitated dipole

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A Positron Electron eXperiment (APEX) collaboration seeks to produce and study electron-positron plasmas in toroidal traps. To understand these electron positron plasmas, a type of pair plasma, we also seek to study the separate non-neutral plasmas (NNP) that will eventually be combined.
Laboratory NNPs typically consist of only one species of charge. In this case, a pure electron plasma is studied. In a device with open magnetic field lines, such as a Penning trap, the trapped plasma can be ejected along the field lines and analyzed. When dealing with a toroidal device and closed magnetic field lines, such as APEX's compact levitating dipole (APEX-LD) [1], NNPs must be analyzed in a different, preferentially non-invasive manner.
Wall probes allow for non-invasive measurements of time-varying density perturbations present in a plasma [2]. However density perturbations do not always exist, therefore additional diagnostics are required to establish the presence of a plasma and determine the confinement time.
In this contribution, the results of a new, non-destructive electron beam diagnostic are presented. Electrons are emitted onto open field line passing through the center of the floating coil and collected on the opposite side. When a NNP is trapped in the dipole, its space charge potential can reflect the electron beam; the collected current therefore provides a way to determine the potential of the trapped plasma as depending on the beam energy.
References
[1] A. Card, A. Deller, M. R. Stoneking, J. v. d. Linden and E. V. Stenson, "FPGA-Stabilized Magnetic Levitation of the APEX-LD High-Temperature Superconducting Coil," in IEEE Transactions on Applied Superconductivity, vol. 34, no. 9, pp. 1-9, Dec. 2024, Art no. 4606709, doi: 10.1109/TASC.2024.3462796.
[2] A. Deller, V. C. Bayer, P. Steinbrunner, A. Card, J. R. Danielson, M. R. Stoneking, E. V. Stenson, "Diocotron modes in pure electron plasmas in the APEX levitating dipole trap," in Plasma Physics and Controlled Fusion, vol. 67, Dec. 2024, doi:10.1088/1361-6587/ad9e70

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