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Design and construction of a levitated dipole trap for pair plasma studies

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Magnetic dipole traps have demonstrated good confinement properties for both non-neutral and quasi-neutral plasmas, making them highly suitable for the creation and study of low-temperature, long-lived electron-positron pair plasmas. To generate such a plasma, the APEX (A Positron-Electron eXperiment) Collaboration is planning to inject positrons (supplied by the reactor-based beam NEPOMUC, then collected into pulses in a buffer-gas trap) into a dipole magnetic field, which is previously loaded with a comparable population of electrons. Our dipole trap is a 15-cm-diameter high-temperature superconducting (HTS) closed coil, which is cryogenically cooled (20 K) and inductively charged (56 kAt, B_{axis}= 0.5 T). Levitation prevents particle losses through the intersection of magnetic field lines with material surfaces (e.g. mechanical supports). By directly exposing the coil to room temperature thermal radiation, we observed a worst-case warming rate that limits available levitation time to 96 min. Simulations have shown that a technique for injecting positrons across magnetic field lines (previously demonstrated in a prototype supported dipole trap) is expected to be transferrable to the higher fields and symmetric geometry of the levitated dipole trap. The construction of the levitated dipole trap itself is nearing completion, with commissioning and electron experiments anticipated to take place by the end of 2022.

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