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Evaporative Cooling in Electromagnetic Radio Frequency Ion Traps

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In 2011, the ALPHA collaboration created and trapped neutral anti-hydrogen particles for the first time in history [1]. Key to this achievement was the demonstration of evaporative cooling of charged particles in a Penning Trap, a cooling method that had not previously been achieved with trapped low temperature ions [2]. Work is currently underway at the University of Calgary to computationally investigate the feasibility of optimum conditions for employing evaporative cooling in Paul-type ion traps, a combination of cooling and trapping that has not been used in the past. Due to the complex ion-ion and ion-trapping field interactions, the system is modelled and equations of motion of particles solved computationally using the RK4 method. This work explored the intrinsic challenges of cooling a system of charged particles constrained by an oscillating field, and showing that, dependent on the precise system parameters, evaporation of particles from a trapped system may or may not reduce the temperature of the remainder of the ensemble. Therefore, an extensive range of simulations have been used to study the evolution of a system of ions trapped in an electromagnetic RF trap under a range of different initial conditions and plasma shapes. For each set of system parameters, the cooling parameters were varied using a Monte-Carlo method to find optimum conditions to achieve evaporative cooling, i.e achieving the highest temperature drop while minimizing the particle loss rate. This presentation will include the results of the work and it's future applications in fields such as spectroscopy and mass measurements will be discussed.

[1] G. B. Anderson et al. (ALPHA Collaboration), Nat. Phys., 558, (2011)

[2] G. B. Anderson et al. (ALPHA Collaboration), Phys. Rev. Lett. 105, 013003 (2010)

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