Experiments with Positronium and Cold Atoms

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Recent progress in manipulating the positronium atom has resulted in accurate state control including excitation to long-lived Rydberg states [1]. The charge exchange reaction between excited positronium and antiprotons is of relevance to antihydrogen production, with two collaborations actively pursuing this mechanism in their experimental programme at CERN [2,3]. Numerical work indicates that the cross-section can be large for excited states of positronium [4], but that the behaviour is not simple [5].

We have recently proposed that cold neutral species could be produced from cold trapped ions via the charge conjugate reaction with an ion [6]. Low temperatures become possible by laser cooling the trapped ions before scattering with positronium, which does not impart significant recoil energy, and thus sufficiently massive neutrals remain essentially as cold as the ions were originally. Species that cannot be laser cooled directly can be sympathetically cooed in the ion trap. By charge exchange with positronium, both charge neutrality and low temperature, which are often desired in precision measurements, could in principle be achieved even in complex species. By a simple scaling of results in [4] the reaction cross section would be sufficiently large to produce a sufficiently dense sample of neutrals for experiments in novel collisions or fundamental tests of symmetry.

The experimental realisation of this proposal will in the first instance allow exploring positronium-ion scattering at low, controllable kinetic energy with species that can be laser cooled directly, with a first goal of understanding the scattering process. Realising this proposal entails combining positronium production and laser excitation with confining and laser cooling ions in an RF-trap. Here, I will present an overview of the proposal and our progress in this project to date.

References

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