Recent Results with Guiding Center Atoms and Ions

Dan Dubin and Eric Bass

Department of Physics, University of California – San Diego, La Jolla CA

This talk will discuss two topics related to guiding center atoms: (I) the rate at which such atoms relax to deeper binding, and (II) the properties of a novel type of guiding center ion. In part (I), we present an analysis of the energy loss rate for guiding center atoms that have passed the kinetic bottleneck at binding energy $\varepsilon \sim 4k_B T$. Energy loss caused by collisions between atoms and free electrons is calculated in two ways: For close collisions, a molecular dynamics simulation gives the energy loss; for large-impact parameter collisions, theoretical expressions based on Fokker-Planck theory are employed. For a finite magnetic field, the energy loss rate scales as $1/\varepsilon$ just as for infinite field, but with a larger coefficient. A statistical description of energy loss by radiation and Stark mixing will also be discussed.

Part (II) of the talk describes a novel type of guiding center drift ion consisting of a neutral atom to which either an electron or a positron is weakly bound by quadrupole and/or induced dipole fields, at sufficiently large radius that it may be described by ExB drift dynamics. Such ions may occur naturally in astrophysical plasmas and may also have been formed in recent antihydrogen experiments. Binding energies and orbital dynamics are described in two limits: (i) a ground state H atom along with an outer charge in a zero-angular-momentum orbital, and (ii) a classical guiding center drift H atom (a proton about which an electron ExB drifts in the Coulomb field) with an electron or positron bound at larger radius. For case (i) the affinity of a positronic H^+ ion is shown via a full quantum calculation to be $2.23\,(B/B_0)^2\, e^2/a$, where $B_0 = 2.35 \times 10^5$ Tesla and a is the Bohr radius. For case (ii) much larger binding energies (of order meV) are found because the induced dipole moment of a guiding center atom is much larger than that of ground state hydrogen.

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