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Nonneutral Plasmas and the Wider World of Physics[1]

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Basic research with nonneutral plasmas has been rich in interdisciplinary connections to the wider world of physics. For example, the creation of laser cooled pure ion crystals involved a combination of ideas from plasma physics and condensed matter physics and experimental techniques from atomic physics. The collaboration of plasma physicists and atomic physicists on studies of these small Penning trap plasmas, liquids, crystals has been an interdisciplinary success story, yielding what are arguably the best understood and best controlled plasmas systems in existence. Current research with these plasmas is attempting to model fusion reactions in correlated dense matter. Another example is the use of magnetically confined pure electron plasma systems to model the 2D incompressible and inviscid flow of ordinary neutral fluids. The precision of 2D vortex dynamics experiments, such as vortex merger, can be higher than with water tanks because the plasma flow is of very low viscosity and is not influenced by a boundary layer at the bottom of the tank. Surprisingly, for certain initial conditions, the decay of 2D turbulence is found to result in a 2D vortex crystal, similar to the 2D vortex crystals observed in other systems, such as superconductors and superfluids. Plasma physicists, atomic physicists, and particle physicists are collaborating at CERN to produce cold antihydrogen for basic physics studies. In these experiments a cryogenic positron plasma and a cryogenic antiproton plasma are mixed, yielding antihydrogen through rapid three body recombination. The experiments generate many interesting theory challenges at the interface of plasma physics and atomic physics. For example, the antihydrogen atoms formed initially are weakly bound and strongly magnetized, and guiding center drift theory provides a natural description of the positron orbit in the atom. Thus, these novel atoms, now called guiding center drift atoms, are rendered integrable using orbit dynamics developed in plasma physics.

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