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Rydberg atoms in ultracold plasmas[1]

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Ultracold plasmas are formed through the photoionization of laser-cooled atoms, or spontaneous ionization of a dense cloud of Rydberg atoms or now molecules[1]. Ultracold plasmas are inherently metastable, as the ions and electrons would be in a lower energy state bound together as atoms. The dominant process of atom formation in these plasmas is three-body recombination, a collision between two electrons and an ion that leads to the formation of a Rydberg atom. This collisional process is not only important in determining the lifetime and density of the plasma, but is also critical in determining the time evolution of the temperature. The formation of the Rydberg atoms is accompanied by an increase in electron energy for the extra electron in the collision, and is a source of heating in these plasmas. Classical three-body recombination theory scales as $T^{-9/2}$, and thus as a plasma cools due to a process such as adiabatic expansion, recombination-induced heating turns on, limiting the temperature [2]. The Rydberg atoms formed live in the plasma and contribute to the temperature dynamics, as collisions with plasma electrons can change the principal quantum number of the Rydberg atom, driving it to more tightly bound states (a source of plasma heating) or to higher states (a source of plasma cooling). If the plasma is cold and dense enough to be strongly coupled, classical three-body recombination theory breaks down. Recent theoretical work [3] suggests that the rate limits as the plasma gets strongly coupled. I will review the role of Rydberg atoms in ultracold plasmas and prospects for probing Rydberg collisions in the strongly coupled environment.

[1] J. P. Morrison, *et al.*, Phys. Rev. Lett. **101**, 205005 (2008

[2] R. S. Fletcher, X. Zhang, and S. L. Rolston, Phys. Rev. Lett. **99**, 145001 (2007

[3] T. Pohl, private communication.

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