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Laser-driven and Magnetized Ultracold Neutral Plasmas[1]

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Ultracold neutral plasmas (UNPs), created by photoionizing laser-cooled atoms just above threshold, stretch the boundaries of neutral plasma physics towards low energies and strong Coulomb coupling. They also offer precise diagnostics and control over plasma conditions, making them useful for validating plasma theory and discovering new phenomena. In this talk, I will describe several experiments with UNPs formed by photoionizing an ultracold gas of neutral strontium atoms. Laser cooling of ions in the UNP [1] yields ion temperatures as low as 50 mK and Coulomb coupling parameters as high as $\Gamma = 11$. This opens new possibilities for studying transport phenomena in strongly coupled systems. Electrons and Sr^+ ions can be magnetized with experimentally accessible fields ($\sim$ 100G). I will describe our use of laser-induced fluorescence to study the expansion of an UNP created in a quadrupole magnetic field. Density and velocity maps provide evidence for trapping of the plasma. Laser forces, in conjunction with magnetic fields, also offer opportunities for controlling plasma hydrodynamic flow and cooling to lower plasma temperatures. [1]"Laser Cooling of Ions in a Neutral Plasma," T. K. Langin, G. M. Gorman, and T. C. Killian, *Science* **363**, 61 (2019).

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