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Impact of Hydrodynamic Expansion on Laser Cooling of an Ultracold Neutral Plasma[1] THOMAS LANGIN, GRANT GORMAN, THOMAS KILLIAN, Rice University — High temperatures and various heat sources make laser-cooling of typical neutral plasmas impractical. However, ultracold neutral plasmas (UNPs), created by photoionizing an ultracold neutral gas, have typical ion temperatures of $\sim$ 1K and minimal heating sources, making them amenable to laser cooling. Using a UNP of $^{88}Sr^{+}$ we have demonstrated the first application of laser cooling in a neutral plasma. After photoionization, UNPs expand hydrodynamically into vacuum over a time $\tau_{exp} \sim 100\mu$s, resulting in the development of an ion expansion velocity field increasing with both time and distance from the plasma center, with typical average terminal expansion velocity of $v_E \sim 40$m/s. The expansion creates an environment that differs significantly from other systems that have been laser cooled. For example, the Doppler shift resulting from the high value of v_T can limit laser cooling to the central region of the plasma, where expansion velocity is minimal. The expansion dynamics depend primarily on the initial plasma size and the detuning of the cooling laser; for judicious choices of these parameters, the plasma expansion can be nearly halted by laser cooling forces, opening new possibilities of neutral plasma confinement and manipulation.

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