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Expansion Dynamics of Ultracold Neutral Plasmas[1]

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Ultracold neutral plasmas [1], formed by photoionizing laser-cooled atoms near the ionization threshold, stretch the boundaries of traditional neutral plasma physics. The electron temperature in these plasmas is from 1-1000K and the ion temperature is around 1 K. The density can be as high as 10^{10} cm^{-3}. Fundamental interest stems from the possibility of creating strongly-coupled plasmas, but recent experimental and theoretical work has focused on the equilibration and expansion dynamics. Using optical absorption imaging [2], we study expansion dynamics during the first 30 microseconds after photoionization. Images record the spatial extent of the plasma, while the Doppler broadened absorption spectrum measures the ion velocity spectrally. The expansion is driven by the pressure of the electron gas, so the ion acceleration depends on the electron temperature. Evidence for terminal ion velocity supports predictions of adiabatic cooling of electrons during expansion [3]. Images confirm the self-similar nature of a Gaussian density distribution. Understanding expansion dynamics is important for plans to laser cool and trap the plasma. This work is supported by the National Science Foundation and David and Lucille Packard Foundation.

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