Fluorescence Spectroscopy and Ion Temperature Evolution in Ultracold Neutral Plasmas

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Plasma ion temperatures and expansion dynamics are studied through fluorescence spectroscopy on Ultracold Neutral Plasmas (UNP). Ultracold Neutral Plasmas (UNP’s) are created by photoionizing laser-cooled atoms; the resulting plasma expands due to the thermal pressure of the electrons. As the plasma expands, both ion and electron species undergo adiabatic cooling. Powerful optical diagnostics are available to study these systems where the initial density profiles, energies, and ionization states are accurately known and controllable. Spatially-resolved fluorescence imaging of Ultracold Neutral Plasmas (UNP) produces a spectrum that is Doppler-broadened due to the thermal ion velocity and shifted due to the ion expansion velocity. Furthermore, sheet excitation of the plasma allows for localized analysis of the system without density variation. Using this technique, it is shown that the plasma undergoes an initial heating of the ions. This effect is combined with adiabatic cooling which dominates at later times in the expansion.