Laser Cooled Neutral Plasmas:
A Laboratory for the Study of Strongly Coupled Systems

T. C. Killian, G. M. Gorman, T. K. Langin, and M. Warrens

Rice University, Department of Physics and Astronomy and Rice Center for Quantum Materials, Houston TX 77096

Strong coupling arises when interaction energies are comparable to, or exceed, kinetic energies, and this occurs in diverse systems such as dense white dwarf stars, strongly correlated electron systems, and cold quantum gases. In all environments, strong coupling complicates theoretical description and gives rise to new, emergent phenomena. Ultracold neutral plasmas (UNPs), generated by photoionization of a laser-cooled gas, are a powerful platform for studying strong coupling in classical systems, and serve as an ideal laboratory model for other strongly coupled plasmas. In this talk, I will present experimental studies of self-diffusion [1] and thermal equilibration [2], and describe the role of strong coupling in these phenomena. I will also present results from the first application of laser-cooling to a neutral plasma [3], which increases the achievable coupling strength. Although the technique we use, optical molasses, is well established, the high collision rates and rapid hydrodynamic expansion of the plasma create a unique environment for laser cooling. Through laser-cooling we have created plasmas with ion temperatures as low as 50 mK and achieved a factor of 4 enhancement in the coupling strength, allowing for experimental benchmarking of new theoretical models and molecular dynamics simulations of transport.

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References

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