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Self-Diffusion and Non-Markovian Dynamics in Strongly Coupled Ultracold Neutral Plasmas[1] TREVOR STRICKLER, THOMAS LANGIN, PATRICK MCQUILLEN, THOMAS KILLIAN, Rice University — Collisional processes in weakly coupled plasmas are well-described by the Landau-Spitzer formalism. Classical plasma theory breaks down, however, in strongly coupled systems because of the non-perturbative nature of particle interactions, and improving our understanding of this regime is an important fundamental challenge. We present experimental measurements of the self-diffusion constant and observation of non-Markovian equilibration for strongly coupled ions in an ultracold neutral plasma (UCNP) created by photoionizing strontium atoms in a magneto-optical trap. Our diagnostic uses optical pumping to create "spin-tagged" subpopulations of ions having skewed velocity distributions that then relax back to equilibrium. A Green-Kubo relation is used to extract the self-diffusion constant from the equilibration curves. With improved time resolution (down to 30 ns), we have explored the early time dynamics of these skewed ion distributions within 100 ns after the optical pumping, where molecular dynamics simulations predict non-Markovian deviations from the exponential velocity damping expected for weakly coupled systems. At longer times, we observe oscillations of the average velocity during the relaxation, which indicate coupling of single-particle motion to collective modes.

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