Disorderly Conduct in Ultracold Atomic Gases

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Quantum optics in ultracold and high-density, but non quantum degenerate, atomic gases is a relatively little explored but promising area of research. Studies of light trapping in coherently prepared samples, enhanced molecule formation, and ultracold plasma physics in the strongly coupled regime are intriguing areas of current activity. Exploration of the role of spatial disorder on light propagation in such systems, including the possibility of novel types of random lasers [1], disorder-mediated formation of subradiant and superradiant configurations [2, 3], and disorder-modified cooperative light scattering [4] are also topics of considerable interest. Recent research with ultracold matter derived from Bose-Einstein condensates has revealed complex matter wave fragmentation and transport phenomena. In beautiful and complementary experiments, one-dimensional Anderson localization of matter waves by quenched disorder has been demonstrated [5]. More recently, incisive measurements by Deissler, et al. [6] have demonstrated a controlled delocalization transition arising from repulsive interatomic interactions.

In this presentation we trace the exploration, from the first observations of coherent backscattering of light in $^{85}\text{Rb}$ by the Kaiser group, of aspects of disorder in the dynamics and interactions of ultracold atomic gases. Recent research on light scattering in the weak localization regime, including coherent control of multiple light scattering will be discussed, along with experimental efforts to observe Anderson localization of light in three dimensions.