Ultracold lithium-chromium mixtures: From mass-asymmetric fermionic matter to paramagnetic molecules

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Quantum mixtures of different atomic species represent compelling frameworks for a variety of fundamental studies and quantum-technological applications, ranging from the exploration of exotic few- and many-body phenomena to the realization of novel molecular species in the ultracold regime.

Here, I will first provide a general overview of the activities of our lab, primarily based on a novel Fermi-Fermi mixture of ^{6}Li alkali and ^{53}Cr transition-metal atoms, and currently focusing onto two main research topics: realization of quantum gases of LiCr molecules, and investigation of strongly interacting fermionic matter in presence of a large mass asymmetry.

I will then discuss in more detail a recent study of transport dynamics of a small sample of ultracold lithium atoms – acting as light impurity particles – released into a large, ideal gas of chromium – that plays the role of a bath of heavy, point-like scatterers. Under strong interspecies interactions, by lowering the temperature we unveil a crossover from normal diffusion to subdiffusion. Simultaneously, a localized fraction emerges in the lithium gas, displaying no discernible dynamics over hundreds of collision events. Our findings, incompatible with a conventional Fermi-liquid picture, are instead captured by a model of a matter wave propagating through a (quasi-)static disordered landscape of point-like scatterers. These results point to a key, enhanced role of quantum interference in heavy-light atomic mixtures, which emerge as versatile platforms for exploring disorder-free localization phenomena solely driven by a large mass difference.