CM / AMO Seminar

Condensed Matter & Atomic Molecular Optical

Thursday, June 14, 2018 → 705 Pupin Hall → 11:00 AM

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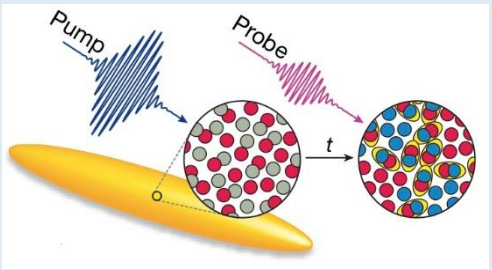
"Time-resolved spectroscopy of quenched repulsive Fermi gases: from polarons to quantum emulsions"

Strong repulsive interactions lie at the heart of a variety of fermion correlation phenomena in condensed matter, such as the ferromagnetism of itinerant electrons. I will report on our experimental investigations of repulsive many-body states in the minimal framework offered by ultracold Fermi gases with tunable short-range interactions and tunable spin polarization. I will first report on the study of repulsive Fermi polarons in a strongly imbalanced resonant spin mixture [1]. The Fermi polaron problem and the associated repulsive quasiparticle are centrally important for the description and the stability of ferromagnetic phases and spin domain walls. Through fast radio-frequency (RF) spectroscopy probing, we observe well-defined repulsive quasiparticles up to very strong repulsion, and we characterise them by extracting all key elastic and inelastic quasiparticle properties. Importantly, we find the polaron energy to exceed the Fermi energy of the bath at a critical coupling strength, while the effective mass diverges and even turns negative, revealing an energetic and thermodynamic instability of the repulsive Fermi liquid.

I will then discuss recent experiments on the out-of-equilibrium dynamics of an ultracold two-component Fermi gas, following a coherent quench to strong repulsive interactions [2]. By employing time-resolved pump-probe spectroscopy and spin density noise correlation measurements, we monitor the evolution of a quenched binary spin mixture under the concurrent action of the ferromagnetic and pairing instabilities. At short time scales and for critical interactions, ferromagnetic correlations appear to overcome the pairing ones, fostering the formation of spin-polarized micro-domains. Over longer evolution times, while pairing processes inhibit further spin de-mixing over larger length scales, the system develops into a novel long-lived state: a quantum emulsion consisting of spin-polarized atomic micro-domains surrounded by molecular pairs. The relaxation of this spatially inhomogeneous many-body phase onto the paired ground state is found to be essentially hindered compared to that of the homogeneous system.

[1] F. Scazza, G. Valtolina, P. Massignan, A. Recati, A. Amico, A. Burchianti, C. Fort, M. Inguscio, M. Zaccanti, and G. Roati, Phys. Rev. Lett. 118, 083602 (2017).

[2] A. Amico, F. Scazza, G. Valtolina, P. E. S. Tavares, W. Ketterle, M. Inguscio, G. Roati, and M. Zaccanti, Manuscript submitted for publication (2018).



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