Superfluid Mixtures, Molecules, and Interferometry with ultracold atomic gases

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Monday, October 2, 2017 - 4:00pm to 5:00pm
PAA A-102

Trapped ensembles of neutral atoms can be cooled to nanoKelvin temperatures to form pristine material with which to model complex quantum systems and build new ones for fundamental physics and applications. For example, strongly-interacting fermions, that govern the physics of high-temperature superconductors and neutron stars, may be explored in the lab using an ultracold gas of lithium atoms. By combining ultracold atomic gases of two different elements (ytterbium and lithium), we realize a mixture of Bose and Fermi superfluids, a system out of reach with liquid helium mixtures. We demonstrate elastic coupling and observe angular momentum exchange between the superfluids. In a separate study, we use optically-induced scattering resonances to link lithium and ytterbium atoms together to form ultracold molecules, with potential applications in quantum information science and ultracold chemistry. Finally, we will report on the development of high precision atom interferometers with Bose-Einstein condensed gases, to measure the fine-structure constant and test quantum electrodynamics. Watch a video of the talk here.