T. Yefsah: *Spin-Orbit Coupling and Heavy Solitons in Fermi Gases*

The coupling of the spin of electrons to their motional state lies at the heart of topological phases of matter. We
have created and detected spin-orbit coupling in an atomic Fermi gas via spin-injection spectroscopy, which
characterizes the energy-momentum dispersion and spin composition of the quantum states. In the presence of s-wave interactions, spin-orbit coupled fermion systems should display induced p-wave pairing and consequently topological superfluidity, where the key ingredient is the existence of topologically protected edge states. A system that similarly supports bound edges states is a fermionic superfluid in a solitonic state. In such system, the gas supports a planar defect – a soliton – at a location where the order parameter changes sign, giving rise to localized bound states. We have created and directly observed long-lived solitons in a fermionic superfluid by imprinting a phase step into the superfluid wavefunction. In order to reveal the filling of these solitons we have studied their oscillatory motion in the trapped superfluid through the BEC-BCS crossover. We have found their oscillation period to be much larger than the trap period and to increase toward the BCS side, signaling an enhanced effective mass which we attribute to a strong filling of the soliton. At the Feshbach resonance, we measure a period which is an order of magnitude larger than available predictions. Our work opens the study of fermionic edge states in ultracold gases.