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Free Fermi gas dynamics with orbital interactions in ultracold Yb

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Ultracold atoms of alkaline-earth-(like) atoms provide quantum gases with particular features stemming from the two-electron structure of the atoms. Most notable are the existence of a very weakly coupled nuclear spin in the fermionic isotopes and the existence of long-lived metastable states among the spin triplet states. The former realizes a very well decoupled internal degree of freedom, allowing for the realization of SU(N)-symmetric quantum gases with a spin larger than 1/2, which allows for novel magnetic states and well-protected spin state preparation. The latter provide additional electronic degrees of freedom which can be used as an orbital degree of freedom for the many-body system. We realize degenerate quantum gases of fermionic ytterbium in optical lattice potentials, using the metastable $^3P_0$ state as an orbital state both to control the interactions between particles and their state-dependent mobility. The ytterbium 171 isotope in particular allows for the creation of non-interacting Fermi gases interacting with a second orbital via both a contact and an antiferromagnetic spin-exchange interaction term. The interactions are governed by a strongly bound dimer state, which we characterize with direct free-to-bound clock-line photoassociation in a magic lattice. Using a state-dependent lattice, we generate a localized orbital which interacts with the Fermi gas, and characterize the relaxation dynamics of both spin degree of freedom as well as charge transport in the presence of the localized orbital "impurity" atoms.