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Pairing in the Fermi-Hubbard model and its relatives

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A key step in unraveling the mysteries of materials exhibiting unconventional superconductivity is to understand the underlying pairing mechanism. While it is widely agreed upon that the pairing glue in many of these systems originates from antiferromagnetic spin correlations, a microscopic description of pairs of charge carriers remains lacking.
In this talk, I will present a mechanism leading to formation of pairs, and its potential realization in different microscopic models. I will discuss possible ways to probe the existence as well as the properties of pairs of charge carriers experimentally in cold atom experiments and numerically. Using state-of-the art numerical methods, we probe the internal structure and dynamical properties of pairs of charge carriers in quantum antiferromagnets through pair spectra. Exploiting the full momentum resolution in our simulations, we are able to distinguish two qualitatively different types of bound states in the t-J model: a highly mobile, meta-stable pair, which has a dispersion proportional to the hole hopping t, and a heavy pair, which can only move due to spin exchange processes and turns into a flat band in the Ising limit of the model. We find qualitatively good agreement with the semi-analytical geometric string theory. We moreover relate the pair spectral function to the properties of Fermi-Hubbard excitons and draw connections to the optical conductivity, thus enabling insights from and connections between theoretical models, quantum simulators, and solid state experiments.

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