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Charge and pair density waves with a unitary Fermi gas in a high-finesse cavity

I will present the experimental study of a unitary Fermi gas in the presence of photon-mediated, long-range interactions in a high-finesse cavity. Above a critical strength of the long-range interaction, the system undergoes a self-organization transition. We map out the phase diagram in the long-range short-range interaction plane, and study the variations of the susceptibility induced by the interactions as a precursor of the phase transition.
Remarkably, the dynamics of self-ordering as the interaction is quenched through the phase transition at variable speed is universal throughout the BEC-BCS crossover, over several orders of magnitude in the quench velocity.

We then extend this scheme to a situation where the cavity operates close to a photo-association transition, realizing optical Feshbach resonance. This allows photons to induce not only an atom-atom but also an atom-pair and pair-pair interaction in the gas. As a result, the density-wave ordering acquires a pair-density wave character. I will present the map of the self-ordering transition in this regime, and discuss the interpretation in terms of pair-density wave order.
Our experiments offer exciting perspectives for the study of the interplay of charge order with superfluidity in a new regime where each order is controlled independently and dynamically.

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