Emergence of many body physics, atom by atom

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We prepare samples of up to 20 fermionic atoms with ultralow entropies in a two-dimensional configuration. We developed a single atom and spin sensitive imaging technique that allows us to detect all atoms of a samlpe either in real, or in momentum space. From such measurements we can infer correlations in the system. In our fermonic system, these are present already in a noninteracting sample and give rise to so-called Pauli Crystals. More interesting correlations arise as soon as interactions in the system are turned on. Now, Cooper pairs and a BCS-like system can be observed to form with p,-p - correlations emerging at the Fermi surface. In our trapped finite system, pairing occurs only at a finite attraction strength, which results in the precursor of a quantum phase transition. To further understand the emergence of many body physics from the few-body limit we are currently exploring a single impurity in a finite Fermi sea to observe the transition from a molecular to a polaronic state.

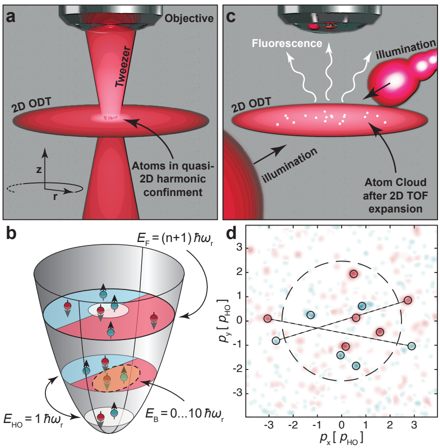

Fig. 1: **a,** Fermionic atoms are trapped in the center of a potential created by superimposing an optical tweezer with a 2D optical trap. **b,** Degeneracy of the 2D harmonic oscillator potential leads to stable configurations when filled with 1+1, 3+3, 6+6 or 10+10 atoms. **c,** To measure the momentum distribution we let the cloud expand in the 2D dipole trap. The atoms are imaged through the microscope. **d,** Single image of the momentum distribution of the 6+6 atom ground state. The dashed black circle indicates the Fermi momentum p_F.

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