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Quantum Optics with Ultracold Fermions

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Control over individual particles has recently enabled the observation of quantum optics phenomena in ultracold atom experiments. In this talk, I will show how to realize entangled-pair sources of massive particles. Using optical tweezers, we implement deterministic sources of lithium atoms in a setting where spins and momenta of individual particles can be detected via free-space fluorescence imaging. In contrast to all photonic implementations, the source operates on fermionic particles, allowing us to explore coherence, many-body interference, and entanglement in a system with negative exchange symmetry. We verify the indistinguishability of the particles through Hanbury Brown-Twiss experiments, in which we detect high-contrast second-order interference and strong correlations at third order. Switching on interactions between the particles, we obtain maximally entangled pairs, which may be used to probe the violation of a CHSH inequality in the experiment. In the future, our techniques may help to measure coherence properties of small atomic clusters and order parameters of fermionic superfluids.