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Measuring the statistics of high-brightness continuous electron beams with sub-ps resolution

Measuring the fermion statistics of free electrons has been a considerable experimental challenge of fundamental interest for many years. The attempts up to now, such as by Tonomura, have remained inconclusive because of the limited temporal resolution of the available detectors. The fermion statistics experimentally show up as electron anti-bunching - i.e., as a changed coincidence rate on a detector compared to the classical Poisson distribution. A direct measurement of the fermion statistics requires determining the arrival time of each particle on a detector within the coherence time, which is in the order of a few fs at most. On the other hand, anti-bunching in an electron beam also occurs at larger time scales due to the Coulomb interaction. While measuring the fermion statistics is particularly relevant from a fundamental physics point of view, determining how the Coulomb interaction affects the beam statistics is of great interest in the growing field of quantum electron optics.
In this work, we propose a new method to detect the arrival time of single electrons from a continuous beam with sub-ps resolution, which overcomes the time resolution limits.
We present the first experimental measurement of the arrival time statistics of a high-brightness 200 keV continuous electron beam generated by the highly coherent Schottky field emission gun of a transmission electron microscope.

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