Interference between two indistinguishable electrons from independent sources

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Very much like the ubiquitous quantum interference of a single particle with itself, quantum interference of two independent, but indistinguishable, particles is also possible. This interference is a direct result of quantum exchange statistics, however, it is observed only in the joint probability to find the particles in two separated detectors. Here we report the first observation of such interference fringes between two independent and non-interacting electrons in an interferometer proposed by Yurke et al. and Samuelsson et al. . Our experiment resembles the âHanbury Brown and Twissâ (HBT) experiment, which was performed with classical light, relaying on cross-correlation measurements of particles arrivals at two different locations. Attempts to perform similar quantum experiments with pairs of single photons encountered fundamental difficulties in generating pairs of indistinguishable photons and synchronizing their arrival in time. In our experiment, two independent and mutually incoherent electron beams were each partitioned into two trajectories. The combined four trajectories enclosed an Aharonov-Bohm (AB) flux (but not the two trajectories of a single electron). While individual currents and their fluctuations (shot noise, measured via auto-correlation) were found to be independent of the AB flux, as expected, the cross-correlation between current fluctuations in two opposite points across the device exhibited strong AB oscillations. This is a direct signature of quantum entanglement between the spatial degrees of freedom of two electrons ("orbital entanglement") even though they never interact with each other.