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Two-Particle Nonlocal Aharonov-Bohm Effect from Two Single-Particle Emitters

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High-frequency single-particle emitters have been realized experimentally in the integer quantum Hall effect regime [1]: the particles are injected into edge states, operating as wave guides, and encounter splitters realized by quantum point contacts. These tools allow for the implementation of complex interferometers in mesoscopic systems showing two-particle interference effects. An example for tunable two-particle correlations is manifest in the electronic analogue of the Hong-Ou-Mandel interferometer [2], where a noise suppression is found due to the Pauli principle. In the work presented here we explore the entanglement production from two uncorrelated sources. We therefore propose a mesoscopic circuit in the quantum Hall effect regime comprising two independent single-particle sources and two distant Mach-Zehnder interferometers with magnetic fluxes. This and the tunability of the single-particle sources allow in a controllable way to produce orbitally entangled electrons [3]. Two-particle correlations appear as a consequence of erasing of which-path information due to collisions taking place at distant interferometers and in general at different times. While the current in this setup is insensitive to the magnetic flux, the two-particle correlations manifest themselves as an Aharonov-Bohm effect in the noise. In an appropriate time-interval the concurrence reaches a maximum and a Bell inequality is violated, proving the existence of time-bin entanglement.

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