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Can Real Forces Be Induced by Interference of Quantum Wavefunctions? IDO KAMINER, JONATHAN NEMIROVSKY, MIKAEL RECHTSMAN, RIVKA BEKENSTEIN, MORDECHAI SEGEV, Physics Department, Technion — In 1958, a revolutionary paper by Aharonov and Bohm predicted a phase difference between two parts of an electron wavefunction even when being confined to a regime with no EM field. The Aharonov-Bohm effect was groundbreaking: proving that the EM vector potential is a real physical quantity, affecting the outcome of experiments not only through the EM fields extracted from it. But is the EM potential a real necessity for an Aharonov-Bohm-type effect? Can it exist in a potential-free system such as **free-space**? Here, we find self-accelerating wavepackets that are solutions of the free Dirac equation, for massive/massless fermions/bosons. These accelerating Dirac particles mimic the dynamics of a free-charge moving under a "virtual" EM field, even though no field is acting and there is no charge: the entire dynamics is a direct result of the initial conditions. We show that such particles display an **effective Aharonov-Bohm** effect caused by exactly the same "virtual" potential that also "causes" the acceleration. Altogether, along the trajectory, there is no way to distinguish between a real force and the self-induced force - it is real by all measurable quantities. This proves that one can create all effects induced by EM fields by only controlling the initial conditions of a wave pattern, while the dynamics is in free-space. These phenomena can be observed in various settings: e.g., optical waves in honeycomb photonic lattices or in hyperbolic metamaterials, and matter waves in honeycomb interference structures.

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