Dephasing in electronic Mach-Zehnder interferometers: Neutrino-like oscillations in condensed matter laboratory

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Abstract:

The recent discovery of the lobe-type behavior in the visibility of Aharonov-Bohm oscillations in electronic Mach-Zehnder interferometers triggered extensive theoretical studies in this field. Many sophisticated theories have been proposed to explain this puzzling effect, which range from the dynamical mean filed method to bosonization technique and even Reimann-Hilbert problem. However, the physics behind this phenomenon turns out to be rather simple and can be explained using intuitive arguments and back-of-the-envelope calculations. Surprisingly, the underlying phenomenon is very similar to neutrino oscillations in high-energy physics: These particles oscillate because they are created in the flavor state, which is not an eigenstate of the Hamiltonian. Similarly, when an electron wave packet splits at a QPC, it excites a collective charge mode, which is not an eigenstate of the Hamiltonian. At the second QPC of the interferometer, this leads to the constructive and destructive interference in the space of collective modes as a function of the applied voltage bias, which explains the lobe-type behavior of the visibility. Apart from this, the strong Coulomb interaction at the edge of a quantum Hall system leads to the phase rigidity phenomenon observed in earlier experiments. This effect is also responsible for the noise-induced phase transition observed very recently. In my talk, I will rely on these simple arguments in order to coherently explain many (seemingly disconnected) experimental observations.