Decoherence of electron waves caused by irreversible electromagnetic

interaction with the charges in a resistive plate

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Controlled decoherence of free electron waves due to Coulomb interaction with a truly macroscopic, dissipative environment (namely: the electron and phonon gas inside a semiconducting plate of 10mm in length) is studied experimentally by electron biprism interferometry. The electron is one of the most elementary particles, and due to the absence of magnetic fields in the setup, spin is irrelevant. Consequently, no inner degrees freedom can be excited and entangled with the center of mass coordinates. Decoherence is exclusively caused by electromagnetic interaction through irreversible deposition of energy into the environment. In the experiment, two parameters are varied, the height of the coherent electron waves above the plate and, in this plane the lateral distance between the coherent beams. The experiment confirms the main features of the theory of decoherence and can be interpreted in terms of which-path information. The quantitative results are compared with the different theoretical models. In contrast to previous model experiments on decoherence, the obtained interferograms directly visualize the transition from quantum to classical behaviour.
For measuring decoherence, the interfering coherent electron waves must be aligned in such a way that they propagate exactly in the same height above the semiconducting plate that causes decoherence. The experiment allows also to choose that the beams cross the decoherence plate in exactly defined, different heights. This results in slightly different energy losses of the coherent waves belonging to single electrons that are brought to interference. By measuring the difference in height for which the contrast of the interference fringes vanishes, a lower limit of the coherent energy width (which may be interpreted as the energy of a single electron in the beam) can be determined.