LBP.IM.P03
Developing a Quantum Electron Microscope - employing the Interaction-Free Measurement to Reduce Radiation Damage

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We develop a new electron microscope based on the interaction-free measurement principle [1,2]. Such a Quantum Electron Microscope (QEM) [3], see Figure below, may enable imaging of biological samples with radiation doses so small that they are non-lethal. The realization of the QEM will require precise control over the quantum motion of free electrons. On this poster, we discuss our approach to build a QEM including the realization of an electron resonator and an electron amplitude beam-splitter. On top of the QEM application, these developments will advance the electron analogue to photon quantum optics.

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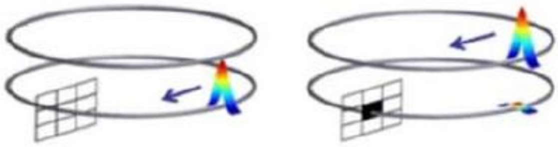

Figure: Interaction-free measurement as proposed in Ref. [3]. Say the electron starts circulating in the upper ring and the upper and lower rings are coherently coupled. After the characteristic coupling timescale, if there is no absorber in the lower ring (left), the electron will completely transfer to the lower ring. If there is an absorber (right), there is no coherent build-up of the electron wave function in the lower ring and it stays in the upper ring, which is a manifestation of the quantum Zeno effect. As the electron can now be measured in the upper ring, the existence of the absorber is inferred without having interacted with the electron. Fig. from ref. [2].