Contribution ID: **246** Type: **Oral presentation**

Interaction Free Measurements in Electron Microscopy

Wednesday, 11 July 2018 11:00 (30 minutes)

Electron microscopy has revolutionized our understanding of biomolecules, cells, and biomaterials, by enabling their analysis through imaging with (near-) atomic-scale resolution. However, the high-energy electrons typically used for electron microscopy are known to cause damage to biological specimens. Specimen damage is related to the fact that image information is shot-noise limited, meaning that a minimum number of electrons is required to form an image with a specified signal-to-noise ratio. Recent advances in quantum metrology might allow us to overcome these resolution limits [1]. For example, by passing an electron many times through a sample, the Heisenberg limit is reached, where the accuracy of a measurement scales as 1/Ne, a √(N_e) improvement over the shot-noise limit. We are following up on the interaction-free measurement (IFM) scheme of Elitzur and Vaidman [2] based on a Mach-Zehnder interferometer. This technique was conceptually extended to success probabilities arbitrarily close to one using an approach analogous to a discrete form of the quantum Zeno effect. We have proposed designs for electron microscopes containing electron wave splitters and mirrors to implement this measurement scheme [3] and are experimenting with subsystems for such a microscope.

A slice of biological material is by no means an absorber of electrons. The typical effect on a transmitted electron is a local change of the phase of the electron wave and a loss of kinetic energy. Since the latter is effectively a detection of the passing electron, it collapses the wave function and thus occurs with a certain probability, usually much smaller than one. This complicates the relation between the information gained and the damage done [4]. We are trying to derive some rules for this but have not yet succeeded.

Acknowledgement

This research is funded by the Gordon and Betty Moore Foundation.

References

[1] Giovannetti, V.; Lloyd, S.; Maccone, L. Science 2004, 306, 1330–1336.

[2] Elitzur, A. C. and Vaidman, L. Found. Phys. 1993, 23, 987–997

[3] Kruit, P. etal. Ultramicroscopy 164 2016, 31–45

[4] Thomas, S.; Kohstall, C.; Kruit, P.; Kasevich, M.; Hommelhoff, P. Phys. Rev. A 2014, 90, 053840.

Primary author: Prof. KRUIT, Pieter (Delft University of Technology)

Presenter: Prof. KRUIT, Pieter (Delft University of Technology)

Session Classification: Workshop on Quantum Foundations and Quantum Information