Creating contrast in electron microscopy using the quantum Zeno effect

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The concept of interaction-free measurements as proposed by Elitzur and Vaidman [1] for photons, should also work with electrons [2]. When built into a transmission electron microscope [3], this may lead to imaging modes with reduced damage. In our scheme, the electron wave is split by an amplitude splitter in a large component (the reference beam) which passes through a hole in the specimen and a small component (the sample beam) that passes through the sample. After the passage, both beams are cycled back to the amplitude splitter and the process is repeated. If the sample has no effect on the beam, the amplitude in the sample beam slowly builds up until it has the full intensity after m cycles. If the sample does have an influence, either on the amplitude or on the phase, the intensity transfer is disturbed by the quantum Zeno effect, and the intensity stays in the reference beam. Using the model explained in [4], the signals in the reference beam and the sample beam can be calculated as a function of the inelastic mean free path and the phase change in the specimen. To get an impression of what kind of images our method would produce, we simulate electron microscopy images of proteins. At the same time we are developing and testing essential components for the multi-pass electron Mach-Zehnder interferometer that needs to be incorporated in the transmission electron microscope.

References:

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