P27: Ghost imaging with electron-photon pairs

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In recent years, time-resolved electron microscopy has garnered increased interest within the scientific community. Particularly, temporal correlation within cathodoluminescence signals have proven to dramatically enhance the useful signal by suppressing background noise [1, 2]. Here, we introduce a new method of imaging at the intersection of quantum optics and electron microscopy.

Ghost imaging, also known as coincidence imaging, of an object is a method in classical and quantum physics that involves constructing an image by gathering information from correlation measurements [3]. To produce correlated electron-photon pairs we use a transmission electron microscope (TEM) working at 200 keV to illuminate a 50 nm silicon membrane. Inelastic scattering of electrons may lead to the emission of coherent photons through a process known as cathodoluminescence [4]. Due to energy and momentum conservation, transmitted electrons and emitted photons are correlated in position and momentum. A custom-made parabolic mirror directs the photons out of the TEM to an optical detection system. The photons interact with absorptive grating lines placed either in the position or momentum plane. Afterwards, they are collected by a bucket detector incapable of directly recording an image.

By energy-filtering the transmitted electrons we detect only those electrons which were involved in the emission of corresponding photons. Then coincident measurements are performed using a time-resolved pixelated direct electron detector (Advascope, Timepix3) and a time correlator (Swabian Instruments, Time Tagger Ultra). The scheme of correlation measurements is shown in Figure 1. As a result, we obtain a ghost image of the grating lines placed in the optical system. It is remarkable that, despite electrons never directly interacting with these grating lines, we are able to perform ghost imaging through correlated electron-photon pairs.

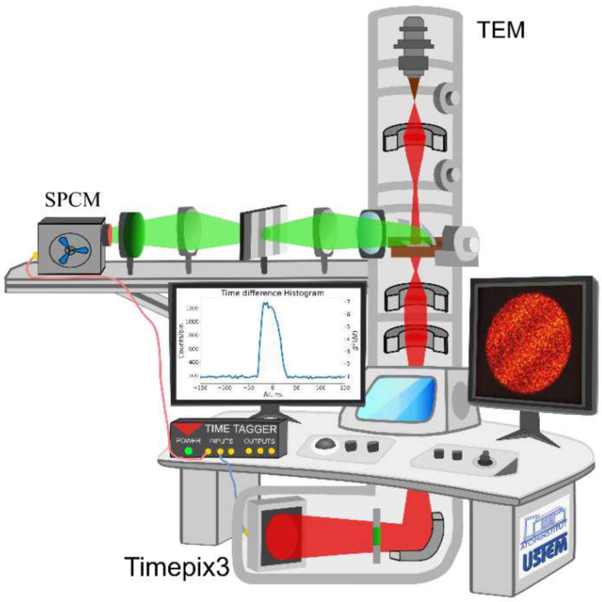

Figure 1. Principal scheme of correlation measurements of electron-photon pairs

[1] Feist et al, Science 377, 6607 (2022).
[2] A. Preimesberger et al, Physical Review Letters 134.096901 (2025)
[3] D'Angelo et al, Physical Review Letters 92.23 (2004).
[4] Scheucher et al, Ultramicroscopy 241 (2022).