

Electron-Photon Entanglement in Electron Microscopy

Alexander Preimesberger^{1,2}, Sergei Bogdanov^{1,2}, Isobel C. Bicket^{1,2}, Phila Rembold²
and Philipp Haslinger^{1,2}

1 University Service Centre for Transmission Electron Microscopy (USTEM), TU Wien,
Austria

2 Atominstitut, TU Wien, Austria

Entanglement is a central resource in quantum technologies, yet it has only recently become accessible in free-electron optics. In my presentation, I will present our recent experimental demonstration of quantum correlations between free electrons and cathodoluminescence photons generated inside a transmission electron microscope [1].

Using 200 keV electrons passing through a thin silicon membrane, we produce correlated electron-photon pairs via transition radiation. A time-resolved single-photon detector and a Timepix3-based direct electron detector allow us to identify coincident pairs and measure their transverse position and momentum correlations. By adapting ghost-imaging techniques [2] and an entanglement witnesses from photonic quantum optics, we quantify these correlations and show a violation of the MGVT separability bound [3], providing evidence for continuous-variable electron-photon entanglement.

We hope that these results will help to make entanglement available as a resource for electron microscopy, enabling novel measurement schemes inspired by photonic quantum optics.

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[2] M. J. Padgett and R. W. Boyd, Philos. Trans. R. Soc. A 375, 20160233, (2017).

[3] S. Mancini, V. Giovannetti, D. Vitali, P. Tombesi, Phys. Rev. Lett. 88, 120401 (2002).