# P32: Simulation-Driven Study of Electron-Cherenkov Photon Entanglement Certification in TEM

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The integration of quantum correlations into transmission electron microscopy (TEM) opens new avenues for advanced imaging and hybrid sensing techniques [1-3], with potential benefits such as low-dose imaging for radiation-sensitive samples and enhanced contrast mechanisms. Despite growing interest in quantum-enhanced electron microscopy [4], entanglement between electrons and photons has not yet been experimentally certified. We present a protocol to certify electronphoton entanglement naturally arising from coherent cathodoluminescence (CL) processes, using mutually unbiased bases in position and momentum [5] for robust, state-agnostic verification. Using simulations based on a Cherenkov radiation model, we describe the interaction between an incident electron and a dielectric material, where the conservation of energy and momentum inherently leads to entanglement between the electron and the emitted photon. We characterize this entanglement through their resulting correlations and assess the feasibility of its certification under experimental constraints, accounting for uncertainties in position and momentum measurements. These simulations establish a quantitative lower bound on the degree of entanglement, enabling cross-platform comparisons.
We conclude that modern TEMs with optical specimen access can be adapted for entanglement verification of electron-Cherenkov photon pairs by implementing appropriate measurement schemes [6, 7]. Our findings highlight the potential of integrating photonic quantum-information techniques with TEM, paving the way for novel quantum-enhanced imaging methods [7].

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