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Quantum Plasmonics with Free Electrons

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Fast electrons offer the means to excite and probe plasmons with an unparalleled combination of space and energy resolutions. In particular, electron energy-loss and cathodoluminescence spectral microscopies are widely used to obtain snapshots of these excitations. Additionally, access to ultrafast plasmon dynamics is possible by recording photoelectrons excited with femtosecond light pulses, while recent experiments demonstrate optical pumping followed by electron-beam probing with similar temporal resolution. In this talk, we will review recent highlights of these techniques and present a unified theoretical description. We will further discuss some exciting phenomena enabled by the quantum nature of the electron-plasmon interaction, including quantum nonlinearities, electron-plasmon entanglement, and vacuum fluctuations. Emphasis will be placed on the potential application of these phenomena for improving and extending spectrally resolved electron microscopy, as well as for on-demand creating and probing of plasmons in integrated devices.