Nanophotonics with Free Electrons

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Electron beams hold a unique position in the quantum photonic Lego because of their role both as a tool to unveil fundamental phenomena and as a resource for the excitation, probing, and control of quantum optical modes at the nanoscale. The ability to modulate the longitudinal and transverse wave function associated with free electrons has recently experienced an impressive boost thanks to the combination of new advances in electron sources/optics –in particular with the use of ultrafast light pulses– and the synthesis of femtosecond electron wave packets. In this talk, we overview key concepts describing the interaction between free electrons, light, and photonic nanostructures, making emphasis on quantum aspects and exploring several exciting challenges and emerging opportunities. In particular, we discuss potential applications in noninvasive spectroscopy and microscopy, sampling of the nonlinear optical response at the nanoscale, manipulation of the density matrices associated with free electrons and confined optical modes, optical modulation of free electrons for the generation of sub-nanometer/sub-femtosecond electron pulses, and improved schemes for electron-driven localized light source operating over a wide range of spectral ranges.

References

[1] F. J. García de Abajo and V. Di Giulio, ACS Photonics 8, 945-974 (2021).

Figures

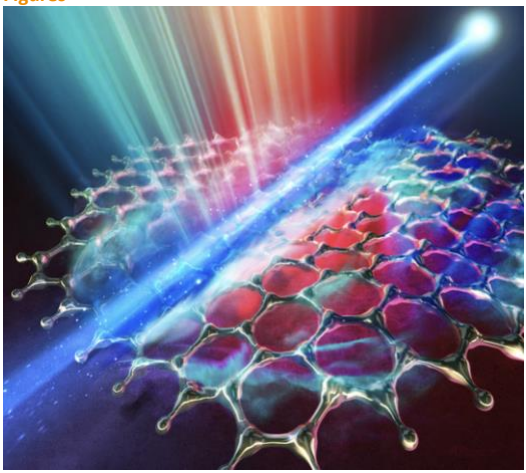

Figure 1: Illustration of a free electron interacting with a confined optical mode and procuding cathodoluminescence, as well as a signal encoded in the transmitted electron spectrum. In the reversed process, under illumination of the optical mode by ultrafast laser pulses, the wave function of the electron can be shaped and its duration compressed down to the attosecond range. Image reproduced from Ref. [1].