

## CONDENSED MATTER SEMINAR

Thursday 6 June at 2.15pm

### “Electrons Interacting with Light and Nanostructures: Towards Quantum Coherent Control with Electrons”

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Interaction of electron waves with light and matter has been a subject of intense studies in the last decades. This research area is reached from the point of view of first principles, due to the interesting quantum phenomena which it covers, but also from practical aspects. Indeed everyday experiments with electron microscopes and free-electron lasers demonstrate this fact. The numerous mechanisms of radiation of free-electron beams, from classical Larmor radiation to coherent x-ray radiation, have opened a new avenue for the design of modern light sources with collimated and coherent radiation properties. Additionally, combining laser and electron guns in electron microscopes have created a plethora of opportunities in characterizing the chemical reactions and near-field distributions of nanostructures using a time-resolved spectroscopy approach, called 4D electron microscopy [1].

In this talk, I will discuss the basics of the electron-light-matter interaction cycle from the first principles. I also shortly review two electron-based spectroscopy tools, the so-called electron energy-loss spectroscopy (EELS) and cathodoluminescence, which have so far enabled us to investigate the photonic density of states in nanostructures at high spatial resolution [2,3]. Moreover, I will describe the 4D electron microscopy and its advantages and shortcomings for the purpose of time-resolved spectroscopy of nanophotonic systems. In addition, our directions in addressing those shortcomings and advancing our methodologies towards spectral interferometry and coherent control of nano-optical excitations in polaritonic systems with electron beams will be addressed [4, 5]. I will also outline my future plans to address the proposed questions, both numerically and experimentally.

#### References

- [1] G. M. Vanacore, A.W.P. Fitzpatrick, A.H. Zewail, “Four-dimensional electron microscopy: Ultrafast imaging, diffraction and spectroscopy in materials science and biology,” *Nano Today* 11 (2016) 228-249.
- [2] N. Talebi, “Interaction of electron beams with optical nanostructures and metamaterials: from coherent photon sources towards shaping the wave function,” *J. Opt.* 19 (2017) 103001.
- [3] N. Talebi, “Electron-light interactions beyond the adiabatic approximation: recoil engineering and spectral interferometry,” *Adv. Phys. X* 3 (2018) 1499438
- [4] N. Talebi, “Spectral Interferometry with Electron Microscopes,” *Sci Rep-Uk* 6 (2016) 33874.
- [5] N. Talebi, S. Meuret, S. Guo, M. Hentschel, A. Polman, H. Giessen, and P.A. van Aken, “Merging transformation optics with electron-driven photon sources,” *Nat. Commun.* 10 (2019) 599.

**Host: Prof Robert Taylor**

**Simpkins Lee Room, Beecroft Building**