Nanophotonic electron accelerators towards electron microscopy

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Nanophotonic dielectric laser acceleration (DLA) is a fast-evolving, emerging field aimed at providing a solution to the miniaturization of electron accelerators, down to the chip-scale [1–3]. Although the average acceleration gradients are limited by the material breakdown threshold (up to ~10 GV/m [4]), this technology currently offers acceleration of superb-quality single-electron pulses (normalized emittance ~100 pm-rad) at kHz and potentially MHz repetition rates, and can be easily implemented at academic-scale costs and settings. The opportunity to design accelerator structures and nanofabricate them in a university clean-room is a great advantage for cutting-edge research in quantum electron-light interaction [5], and to the recent proposals for the temporal modulation of electron wavepackets in the attosecond regime, potentially soon in the MeV energy range. In fact, so far, this experimental venture into DLA has been mostly based on electron microscopes, which provide the electron source, beam-forming and injector unit.

Considering this starting point, these chip-scaled accelerators can be naturally considered as a basis for advanced, high-energy, ultrafast electron microscopy of thick samples. As such, building-scale high-energy (e.g. the 3 MeV Hitachi microscope) electron microscopes could one day potentially be miniaturized and installed in any university lab.

In this talk, I will give an overview of the current state of nanophotonic DLA research, with the different schemes being pursued both theoretically and experimentally, some recent proposals and application directions, and the latest results in the sub-relativistic (~30 keV) regime [6–9].

References

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