Catching Electrons in the Act: Electron Motion Control and Imaging

Abstract:

In the last decade, the real-time studies of electron dynamics in matter becomes increasingly important for the accurate clocking of microscopic phenomena as well as for the ultrafast switching of functionalities in nonlinear optical devices[1-4]. These studies paved the way to exploring electron dynamics on its action time scale, but relevant techniques cannot provide direct access into the dynamics of the nonlinear response of bound electrons to optical fields. Here we demonstrate the world first optical attosecond pulses synthesized in the visible and nearby ranges, permit the access to the sub-fs probing and control of bound-electronic response[5]. This study paves the way to novel electronic spectroscopies of bound electrons in solids[6] as well as to light-based nonlinear photonics operating on sub-fs time scales and PHz rates.

On the other hand, recently the advancement in ultrafast electron microscopy has allowed recording snaps of temporally-evolving systems, extending the imaging from the three spatial dimensions to the fourth temporal dimension, which provides real-time access to the microscopic motions and radically changed our insight into the workings of this microcosm. Hitherto, imaging the electronic structure dynamics remains beyond the reach due to the lack of the desired temporal resolution. In the second part of the talk, I will show our recent work to enhance the typical temporal resolution of UEM by more than an order of magnitude (16 times) by generating ~ 30 fs electron pulses, accelerated at 200 KeV, via the optical-gating approach, with sufficient intensity for efficiently probing the electronic dynamics of matter. Moreover, we investigate the feasibility of attosecond optical gating to generate subfemtosecond electron pulses utilizing the demonstrated optical attosecond pulse[5]. Attaining the attosecond temporal resolution in electron microscopy hold the promises for establishing the "Attomicroscopy" to allow the imaging of electron motion in the act.

References

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