CFEL SCIENCE

SEMINAR

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CFEL-bldg. 99, seminar room IV

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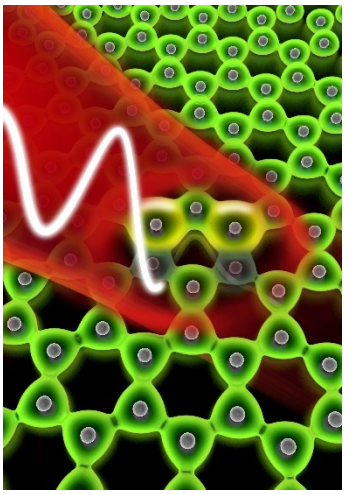
Diffractive imaging of strong-field-driven electron dynamics in graphene

The most direct way to understand the interaction of light with matter is to observe the motion of electrons in space and time. The ultimate goal of such imaging is to see how electron density changes on the atomic time scale within a fraction of a laser cycle. Recent breakthroughs in ultrafast electron and X-ray diffraction may soon enable such measurements. Using graphene as an example material, we show with simulations that ultrafast electron diffraction can provide a time-dependent record of charge-density maps in condensed matter [1]. Such real-space measurements promise subcycle and sub-atomic resolutions, and they can reveal light-driven electron dynamics that are not easily accessible by conventional spectroscopic methods.

We solve the time-dependent Schrödinger equation in three spatial dimensions for independent electrons moving in a local “effective” lattice potential $V(\mathbf{r})$ that is periodic in any plane parallel to the atomic plane. Our simulations predict that a 10-fs laser pulse with a central wavelength of 2.1 μm and an amplitude of 0.5 V/Å, which is below the damage threshold of graphene, will induce significant and localized changes in the electron density. These changes are detectable by ultrafast electron diffraction with a 1-fs electron pulse. Our analysis reveals a complex picture of graphene’s response to optical excitation. Even though Bragg-peak intensities generally do not provide sufficient information to retrieve electron density, we demonstrate how available spatial symmetries can be utilized for successful retrieval of real-space dynamics.



References

[1] V. S. Yakovlev, M. I. Stockman, F. Krausz, P. Baum. Scientific Reports 5, 14581 (2015).

Host: Robin Santra – CFEL-DESY Theory Division