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SFB 1242 Nichtgleichgewichtsdynamik kondensierter Materie in der Zeitdomäne

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Transient lensing from an electron gas imaged by ultrafast electron microscopy

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Transmission electron microscopy (TEM) has become a powerful technique to study the structure of materials at the nanoscale. The time resolution in TEM, however, is typically limited by the maximum frame rate of the detector, which is at best in the kHz regime. Ultrafast TEM combines the high time resolution of laser spectroscopy with the excellent spatial resolution of electron microscopy techniques. The structural and electronic changes in the material are initiated by fs laser pulses, which are followed by similarly short photoelectron pulses for probing the dynamics by means of imaging, diffraction, or electron spectroscopy. In this talk I will present our dynamic environmental TEM setup at UIUC, and I will demonstrate its first application in the field of “plasma lensing” [1]. In our experiment, we generated a hot three-dimensional electron gas by two-photon emission from a copper surface in vacuum. After a prompt Coulomb explosion, the subsequent dynamics is characterized by a rapid oblate-to-prolate shape transformation of the electron gas, and periodic and long-lived electron cyclotron oscillations inside the magnetic field of the objective lens. In this regime, the collective behavior of the oscillating electrons causes a transient, mean-field lensing effect and pronounced distortions in the images. We derive an analytical expression for the time-dependent focal length of the electron-gas lens, and perform numerical electron dynamics and probe image simulations to determine the role of Coulomb self-fields and image charges. This work inspires the visualization of cyclotron dynamics inside two-dimensional electron-gas materials and enables the elucidation of electron/plasma dynamics and properties that could benefit the development of high-brightness electron and X-ray sources.

[1] O. Zandi, A. E. Sykes, R. D. Cornelius, F. M. Alcorn, B. Zerbe, P. M. Duxbury, B. W. Reed, R. M. van der Veen, accepted in Nat. Commun. (preprint at https://arxiv.org/abs/2001.01389)

Für diese Zeit steht eine Kinderbetreuung nach vorheriger Anmeldung zur Verfügung.

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