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# Ultrafast meets Real Space – a femtosecond and sub-Angstrom view of molecular dynamics

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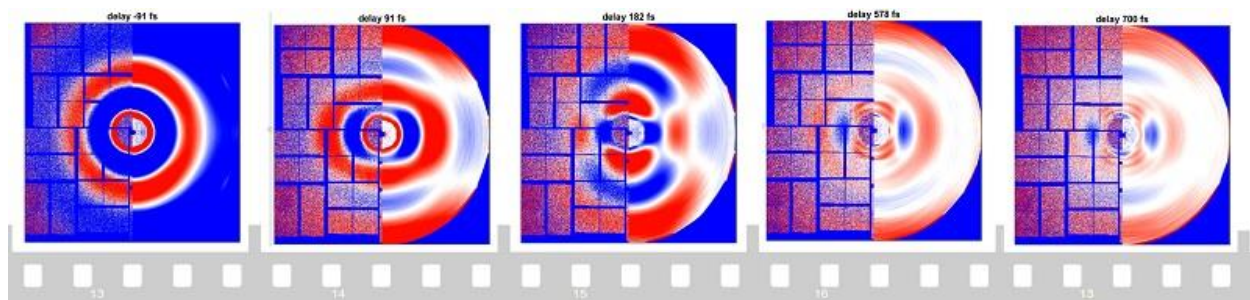
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## Abstract

Ultrafast science is one of the main arenas for scientific advancement across physics and chemistry. At the frontier of ultrafast research, X-ray free-electron lasers (XFELs) are becoming transformative tools that enable imaging and spectroscopy at atomic length and time scales. However, directly resolving in real-space multiple atomic and electronic motions in molecules de-novo is still limited by the photon energies used and finite detector range, which led signal interpretation to mostly rely on modeling and simulations of specific excitation pathways or processes, restricting the complexity of the system and types of dynamics under study.

We demonstrate imaging of atomic motions and structure dynamics of molecules in the gas and condensed phase creating "molecular movies" – sub-Angstrom and femtosecond resolved images of coherent nuclear motion, disentangling single and multiphoton absorption processes, capturing the microscopic details of chemical dynamics from rovibration and dissociation to solvation and decoherence. We introduce model-free approaches to recover and super-resolve motions leveraging scattering signal priors and implement them on systems of increased complexity. We will discuss the opportunity to realize the fidelity of current ultrafast scattering experiments in table-top environments, a capability that can transform several areas of research, and have an important societal impact on applications such as catalysis, and quantum materials.

Going beyond atomic motions, as part of the XLEAP team, we created and characterized the first X-ray attosecond pulses in XFELs, and used them to demonstrate attosecond coherent electronic dynamics in Auger-Meitner decay. We will discuss the opportunities and challenges of using hard X-ray atto-scattering to image electronic currents in molecules in real space and introduce the first steps made toward that grand challenge.



ההרצאה תתקיים ביום רביעי, ה- 12.01.22 בשעה 12:30

באודיטוריום המכון למצב מוצק, קומת כניסה

**The lecture will take place on Wednesday 12.01.22 at 12:30  
at the Solid State Institute Auditorium, entrance floor**

**Host: Associate Professor Ido Kaminer**