Joint Theory Seminar European XFEL, CFEL & University of Hamburg



Thursday, 09 March 2023, 16:00 XHQ/E1.173, in hybrid mode

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## Dynamics in Warm Dense Matter driven and probed by FEL radiation

X-ray free electron lasers are a perfect tool to observe the atomic scale dynamics in nonequilibrium systems. Similar to chemical reactions or biological settings, these properties can also be used to study warm dense matter, a region of complex states with densities comparable to solids and temperatures around 1 eV naturally occurring in the interior of planets, during laser-driven material modifications and transiently inertial confinement fusion experiments. Here, the energy scales of thermal excitations, the electron Fermi energy, the energy of interaction between ions and also typical binding energies all overlap and prohibit most perturbative approaches to its properties. Studying the dynamic response of such systems reveals many properties otherwise hidden or hard to probe in equilibrium. Moreover, WDM states can only be created dynamically as transient states in the laboratory requiring some basic knowledge of the dynamics even for equilibrium experiments.

In this talk, a short overview of the relaxation processes driven by ultra-short radiation pulses is given. For the first time, FELs offer the possibility to investigate the full kinetics of the electron dynamics in dense systems followed by an equilibration of the band occupation in solids or ionisation kinetics in plasmas. Although first results have been observed these experiments are very challenging both technically to resolve the time scales involved and theoretically to develop the analysis tools required. Thus, the longer time scales of electron-ion or electron-phonon temperature equilibration and the arrangements of atom/ions into new phases have been investigated more intensely. In the talk, examples from each relaxation stage will be discussed with special focus on the theoretical support for the analysis needed. In particular, the electron dynamics in plasma and heated gold followed by the energy transfer to the ions as well as the formation of diamonds in shocked hydrocarbons will be discussed with special emphasis how FELs enhance our understanding in the dynamics of WDM.

## Host: Nils Brouwer

## Zoom link:

https://xfel.zoom.us/j/93461314107?pwd=bWhnYkpZcml1RVdJRFErY0dtQ3l1Zz09 Meeting ID: 934 6131 4107 Passcode: 371426