INVITED PRESENTATION #78

Non-equilibrium dynamics during warm dense matter formation

Byoung-Ick Cho[1]

[1] *Gwangju Institute of Science and Technology, Republic of Korea*

The ultrafast absorption of laser energy in condensed matter results in strongly out-of-equilibrium material conditions, which evolve into warm dense matter (WDM). Understanding the fundamental processes of ultrafast energy relaxation and structural evolution in these extreme systems is crucial for a wide range of fields, from laser nano-surgery to laser-fusion research.

The generally accepted concept for the response of systems irradiated by femtosecond laser pulses is that the optical pulse directly excites electrons, which quickly thermalize, establishing a finite electronic temperature in a few tens of femtoseconds, while the lattice remains cold. The two subsystems then equilibrate through electron-phonon coupling, which is the basic premise of the two-temperature model (TTM). This framework has been widely applied to calculate optical and thermophysical properties of laser-irradiated matter, develop advanced models for thermal and nonthermal melting, and interpret data from various experiments. However, the electronic system's detailed dynamics might be more complex than described by the simple TTM.

This contribution presents measurements of XFEL absorption of WDCu, and the optical reflectivity of WDAu irradiated with femtosecond laser pulses. The measurements for the WD noble metals ($\approx$1 eV/atom) reveal the rich dynamical features of nonthermal electrons and vacancies and their interactions with the lattice. The improved modeling of electron dynamics, which includes the recombination of nonthermal electrons and the dynamic shift of the excited valence band, successfully reproduces the key features observed in the measurements. These findings shed light on improving our understanding of the ultrafast population balance between conduction and localized electrons in materials and related transport properties under extreme temperature and pressure conditions.

Acknowledgements

This work received support from the National Research Foundation of Korea (NRF2019R1A2C2002864, NRF-2020K1A3A7A09080397).

Presenting Author Email Address: *bicho@gist.ac.kr*