Inelastic X-ray Scattering under Extreme Pressures

Hokwang Mao*[1,2]

[1]Center for High Pressure Science and Technology Advanced Research
[2]Geophysical Laboratory, Carnegie Institution for Science

During the past two decades, an impressive array of synchrotron inelastic x-ray techniques has been developed and integrated with high-pressure experimentations for understanding of atomic, electronic, and magnetic structures and their relationships to materials properties under pressure. *High-pressure x-ray emission spectroscopy* provides information on the filled electronic states of the compressed samples. *High-pressure x-ray Raman spectroscopy* reveals pressure-induced chemical bonding changes of the light elements. *High-pressure medium-resolution inelastic x-ray scattering spectroscopy* accesses the high-energy electronic phenomena, including electronic band structure, Fermi surface, excitons, plasmons, and their dispersions. *High-pressure high-resolution inelastic x-ray scattering spectroscopy* accesses the high-energy electronic phenomena, including electronic band structure, Fermi surface, excitons, plasmons, and their dispersions. *High-pressure resonant inelastic x-ray scattering spectroscopy* probes shallow core excitations, multiplet structures, and spin-resolved electronic structure. *High-pressure nuclear resonant x-ray spectroscopy* provides phonon densities of state and time-resolved Mössbauer information. These tools integrated with hydrostatic compression, laser heating, and cryogenic cooling, have enabled investigations of structural, vibrational, electronic, and magnetic properties that were unimaginable in the past century. With the high-energy x-ray probes in-and-out the pressure vessel and analyzing the energy loss, we can now study samples under extreme pressures in the soft x-ray to vuv energy range and in the full momentum range that were previously only accessible at zero pressure and zero momentum, respectively. Some challenging examples include the electronic bandgap of hydrogen, excitonic dynamic of helium, and plasmon dynamic of sodium at extreme pressures.

*Corresponding author: hmao@carnegiescience.edu