Extreme states of matter are routinely created in the laboratory by the interaction of a high intensity laser with a solid. Such states are created in order to study scenarios relevant to astrophysical phenomena, inertial confinement fusion (ICF), equation of state (EOS) and opacity models. Solid density material with pressures above a megabar and temperatures of thousands of Kelvin is known as warm dense matter (WDM) and lies in the region of the phase space diagram between traditional solid state and plasma physics. Since expansion techniques are no longer applicable and neither the kinetic nor the potential energy can be treated perturbatively studying WDM represents a major challenge experimentally, theoretically and computationally.

Experiments in WDM generally assume the material to be in local thermodynamic equilibrium however, due to preferential and rapid heating of one subspecies over another during formation, this is quite often not the case. It is known that the current models used in this region such as Spitzer or Brysk underestimate the relaxation time and new models have been developed to compensate. The time scale over which the energy relaxation processes occur is unknown and of vital importance to work in this field. Here we show through x-ray scattering of warm dense graphite that the timescales associated with temperature relaxation can be as long as hundreds of picoseconds and should be accounted for in any high energy density experiment.
