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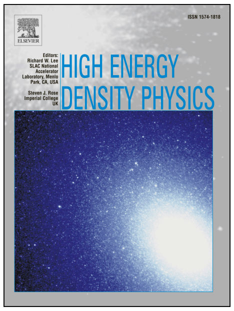

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ACCEPTED MANUSCRIPT

Electron-Ion Temperature Equilibration in Warm Dense Tantalum

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Abstract
We present measurements of electron-ion temperature equilibration in proton-heated tantalum, under warm dense matter conditions. Our results agree with theoretical predictions for metals calculated using input data from *ab initio* simulations. However, the fast relaxation observed in the experiment contrasts with much longer equilibration times found in proton heated carbon, indicating that the energy flow pathways in warm dense matter are far from being fully understood.

1. Introduction

Warm Dense Matter (WDM) is an area of research attracting increasing interest, both in terms of theoretical descriptions [1,2,3,4] and experimental studies [5,6,7,8,9]. Falling between the better-understood states of condensed matter and plasma, it is characterised by temperatures of $\sim 1 - 10$ eV and densities near to that of solids. This gives a coupling parameter (*i.e.*, the ratio of the potential to the thermal energy of the ions) of order unity, such that neither the thermal nor potential energy terms can be treated as perturbations to a known solution, as is the case in other regimes. Despite the difficulties, knowledge of WDM is crucial to inertial confinement fusion (ICF) research [10.11], as well as in the study of exoplanets and other astrophysical objects [12,13].

In general, experimental studies of WDM use a rapid heating mechanism, with properties of the material probed at timescales comparable to, or even shorter than the timescale of the ionic motion, such that the density is that of the original (pre-heated) solid, while the temperature has risen quickly enough to push the matter into the WDM regime. These mechanisms tend to preferentially heat either the ion subsystem, in the case of shock driven samples [14,15], or the electron subsystem for illumination by lasers or charged particles. In both of these instances, there is a finite, but poorly known, amount of time needed for the temperatures of the respective subsystems to equilibrate and the material to reach local thermodynamic equilibrium. Only after this time, but before significant expansion and cooling has occurred, can results obtained from the material be meaningfully related to steady-state WDM conditions, such as those found in planetary cores.

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