Modelling Time-Resolved X-ray Absorption Measurements

R.A. Baggott[1], B. Kettle[1], S.J. Rose[1,2] and S.P.D Mangles[1]

[1] *The Blackett Laboratory, Imperial College London, UK*
[2] *Department of Physics, University of Oxford, UK*

Methods to create warm and hot dense matter in the laboratory typically generate non-equilibrium conditions, with energy being deposited initially in either the electron or ion populations [1]. An understanding of energy transfer mechanisms is therefore required in order to interpret and design such experiments. Furthermore, measurements of equilibration rates can inform our understanding of the physics governing wider transport processes in dense plasmas. However, our understanding of this area remains incomplete. Experiments have yielded widely differing results, suggesting a dependence on both material and the initial heating mechanism [2]. Theoretically, a number of approaches within both plasma and solid-state frameworks have been applied [3,4].

The bright betatron x-rays produced by laser wakefield accelerators can have durations of order 10fs and are therefore ideally suited to probe non-equilibrium processes in dense plasmas [5]. The broadband spectrum produced is smooth over a wide range of energies up to tens of keV and therefore lends itself well to x-ray absorption measurements. Measurements of structure near to absorption edges (XANES) can yield information about the electron and ion temperatures [6], allowing betatron radiation to probe temperature equilibration on sub-picosecond timescales.

Here, we present modelling and preliminary experimental results demonstrating the feasibility of measuring temperature equilibration using a betatron x-ray probe. Using *ab initio* simulations alongside theoretical predictions, we examine to what extent a proposed experimental setup should be able to distinguish between existing models for electron-ion coupling (e.g. Spitzer, coupled-mode [3], two-temperature *ab initio* [4]). Furthermore, we discuss developments in modelling electron-ion energy transfer at the boundaries between plasma and solid-state.

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