Modelling non-thermal XFEL heating of Iron

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Over the past two decades, X-ray free-electron lasers (XFELs) have made significant progress, achieving peak brightness in the XUV and X-ray regions that were previously only attainable in the optical and infrared ranges. This advancement has opened up new possibilities in high-energy density science. It enables the creation of solid-density plasmas with larger volumes, greater uniformity, and well-defined properties, including temperature and density. XFEL heating proceeds through photoionisation and thermalisation, and as such initially creates a non-thermal electron distribution.

In the last years, several experiments have been focus in the creation of solid density plasmas of mid-Z materials, especially transition metals. Since collisional models have been proven to be a successful method to understand the time resolved atomic kinetics, we have adapted the non-thermal collisional radiative model BigBarT [1, 2, 3, 4] in order to simulate arbitrary elements.

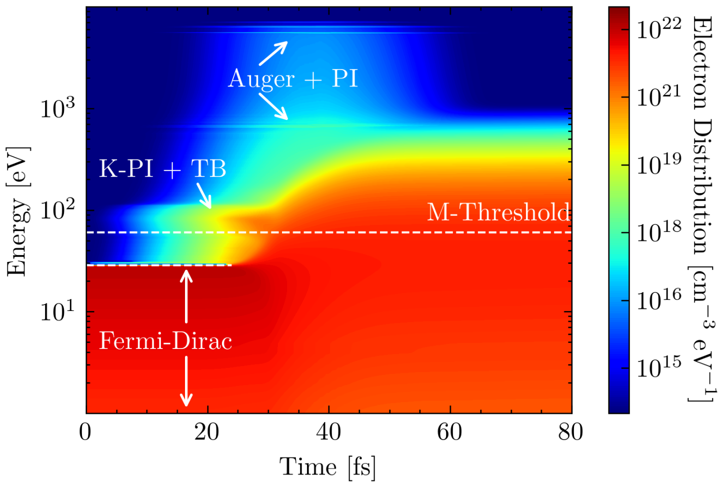

Figure 1. Electronic distribution temporal evolution of an Iron XFEL produced plasma, for a 15 fs FWHM pulse at 5×10^{17} W/cm^2

We investigate the effects of inelastic thermalization in iron under intense X-ray irradiation using the atomic model BigBarT , suited for the self-consistent evolution of the electron continuum, including degeneracy effects. A typical evolution of the distribution function is showed in Figure 1, for a 15 fs FWHM pulse at 5×10^{17} W/cm^2, and an incoming photon energy of 7200 eV. Our study focuses particularly on collisional M-shell ionization, which we identify as the most efficient relaxation process of non-thermal electrons. Comparison of calculated spectra with data could be used to refine collisional cross sections, that are otherwise difficult to compute due to their proximity to the continuum and the associated plasma screening effects.

References

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