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Atomic kinetics in solids under strong XFEL irradiation

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The role of elementary processes during interaction of short XUV free-electron laser pulses with solid material is studied by means of a specific collisional radiative model (CRM) without spatial dimension applied to solid aluminum. The calculation of the energy deposition requires a proper model for the bound electron kinetics as the pulse is mainly absorbed via photoionization of bound electrons. We have modified a classical CRM with detailed atomic physics to reproduce the density effects of continuum lowering and account for the processes involving the valence band. It allows us to treat the transition from solid to warm dense matter. The free-electrons, initially in the valence band,are described by a Fermi-Dirac distribution and are coupled to the bound electrons kinetics through collisional processes. We found that the absorption is highly non-linear with respect to the photon energy and the XFEL intensity. The main elementary processes at stake are thephotoionization, the Auger decay, the three-body recombination and the collisional ionization. A change in the XFEL parameters modifies the competition between these processes and thus, the electron kinetics and the absorption. We also studied the expansion of the matter after irradiation with the code X-RIM coupling detailed configuration kinetics to a 1D Lagrangian hydrodynamics treatment. The study of 0D and 1D calculations allows us to identify the different relevant mechanisms responsible for the matter evolution.

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