Probing dense plasmas with high harmonics

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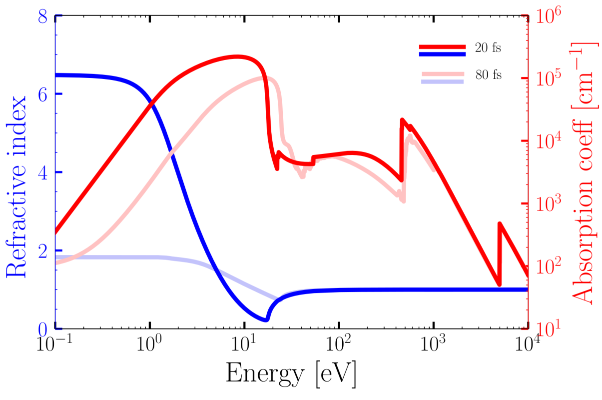
The advent of X-ray free electrons laser opened up new opportunities in the study of warm dense matter. With intensities previously achievable only by infrared and visible lasers, XFELs facilitate the creation of matter with precisely better defined properties, such as temperature and d ensity. Recently, there has been a particular focus on the generation of dense plasmas from mid-Z materials, especially transition metals.

These experiments are typically complemented by collisional radiative models (CRMs), which have proven to be useful tools for understanding the temporal evolution of the sample. Recently, the non-thermal CRM BigBarT [1, 2, 3, 4] code has been extended to simulate arbitrary materials while maintaining a self-consistent approach for evolving non-thermal electron distributions and incorporating degeneracy effects. Additionally, time-dependent indexes of refraction have been derived using the Kronig-Kramers relations, allowing for the investigation of electromagnetic wave propagation in the plasmas.

The dielectric function is used to calculate the polarisation using the Havriliak–Negami method. This polarisation is used to calculate the propagation of a harmonic HHG beam in a target which has been isochorically heated by the XFEL. For this calculation, Maxwell's equations are solved numerically with a Godunov method with adaptive mesh, which allows to simulate the complete physical system during the whole HHG pulse. The phase differences of the outgoing HHG beam can be measured on a wavefront detector and the spatial variation of the sheet electron density can be derived. We present the results of simulations of this approach to measure density profiles in dense plasmas with HHG beams.



Refractive index and absorption coefficient for Ti illuminated by a XFEL pulse of I=10^{17} W/cm^2, FWHM=30 fs and hν=6 keV.

References

[1] A. G. de la Varga et al, HEDP **7**, 163-168 (2011).

[2] A. G. de la Varga et al, HEDP **9**, 542-547 (2013).

[3] Van Den Berg Q. Y. et al., Phys Rev Lett **120**, 055002 (2018).

[4] Ren S. et al., Comm Phys **6**, 99 (2023).

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