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Time-dependent radiation emission from an X-ray laser-produced plasma

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With new ultra-intense lasers, such as the XFEL, the effects of non-thermal electronic distributions (EDF) are important. This deviation from the thermal distribution comes from the time dependence of the EDF and atomic populations. To study this problem, it is necessary to couple the time evolution of the atomic populations with the time evolution of the EDF and of the radiation energy distribution. We have studied the change in the radiation emission due to the time evolution of the EDF in dense plasmas, initially a Fermi-Dirac distribution, generated by XFEL. To numerically simulate this process, we coupled the time evolution equations of the atomic populations with the Fokker-Planck time equation for electrons with degeneracy. This implies recalculating at each instant all atomic process rates, as well as the coefficients and independent terms of the FP equation.

A signature of non-equilibrium processes is the emission of radiation differentiated from that of equilibrium. We present and explain the differences between such emissions with and without time dependence, pointing out the possibility of measuring the time effects of the EDF. To study these time-dependent phenomena, we used the atomic physics code BigBarT which has been validated for the calculation of spectral opacities for plasmas in equilibrium. In the figure below we show the time-integrated emission spectrum for thermal and non-thermal EDF. Two low-intensity signals are seen in the non-thermal case that are missing with thermal EDF. This opens the possibility of measuring non-thermal effects in dense plasmas. Furthermore, we will present results for the transmission of XUV electromagnetic radiation in time-varying refraction index of a dense plasma generated by XFEL.

References

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