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Integration of PIC simulations and magnetic-sublevel atomic kinetics for plasma polarization spectroscopy

PETER HAKEL, University of Nevada, Reno

Interactions of high-intensity ultrashort-duration laser pulses with matter often result in the creation of highly non-equilibrium plasmas. Electrons and other particles can be accelerated to high velocities and can be very directional. Studies of such anisotropic plasmas are important both from the fundamental research point of view and also because of their relevance to such problems as fast ignition. In this work we study some aspects pertaining to the spectroscopic modeling of anisotropic plasmas. We investigate the possible diagnostic value of polarized line emissions driven by energetic plasma particles. We build on our previous experience with magnetic sublevel atomic kinetics models for polarized line emissions [1,2]. In particular, we discuss the details of constructing more accurate sublevel models that incorporate results of PIC simulations [3] of laser-matter interactions and the formation of directed energetic particles. New analytic expressions for the calculations of sublevel collisional atomic rates are given and their performance evaluated. These techniques make the calculation of collisional rates more accurate and realistic than before. Finally, we discuss the degrees of polarization of selected spectral lines and their sensitivity to the details of the particle distributions.

[1] P. Hakel et al., Phys. Rev. A 76, 012716 (2007).
[2] P. Hakel et al., Phys. Rev. E 69, 056405 (2004).
[3] Y. Sentoku and A. J. Kemp, J. Comput. Phys. 227, 6846 (2008).