Calculations on the stopping power of the warm dense matter at the Bragg peak

F. Chacón-Rubio, J. Vázquez-Moyano , M.D. Barriga-Carrasco

E.T.S.I. Industrial Universidad de Castilla-La Mancha, Ciudad Real, Spain

Dense plasmas in the Warm Dense Matter (WDM) regime are of great interest as a probe of stopping power theories. WDM is extremely difficult to treat theoretically due to the simultaneous appearance of quantum degeneracy, Coulomb correlations, and thermal effects. Also, the coexistence of plasma and condensed phases force stopping power theories to consider both, free and bound electrons. Many stopping power models in plasma use density, temperature, and ionization state as input parameters. Therefore, an accurate description of the plasma is necessary to perform these calculations correctly. As these values are not always available from the real plasma, hydrodynamic simulation become a handy solution to obtain key plasma parameters. In this study, we have performed a hydrodynamic simulation based on a proposed experiment [1] with the help of a hydrodynamic code. The basic physics processes included in the code employed are hydrodynamic equations, thermal flux, electron-ion relaxation, electron collisions and laser energy deposition. We present the profiles of density, temperature and ionization obtained and discuss their validity as well as the shortcomings of the simulation. Finally, stopping power calculations with our and other models using an ad hoc combination of free and bound electrons. The models considered are T-Matrix [3], Li-Petrasso [4], Vlasov [5], SSM [6], Mehlhorn [7] and Zimmerman [8]. With this, we expect to test the validity of the stopping power models considered in general, and of our model [2] in particular, in WDM near the Bragg peak.

[1] J.I. Apiñaniz et al. Scientific Report 11:6881 (2021)
[2] M.D. Barriga-Carrasco, F. Chacón-Rubio, C.C. Montanari. In publication process (2021).
[3] D. O. Gericke and M. Schlanges. Physical Review E, 60,904 (1999).
[4] C.-K. Li and R. D. Petrasso. Physical Review Letters, 70, 3059 (1993).
[5] T. Peter and J. Meyer-ter Vehn. Physical Review, A, 43, 1998 (1991).
[6] C. Deutsch, et al. The open plasma physics journal, 3 (2010)
[7] T.A.Mehlhorn. Journal of Applied Physics 52, 6522 (1981)
[8] G. B. Zimmerman. Tech. Rep. Internal Report No.UCRL-JC-105616 (1990).