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Numerical investigation of bremsstrahlung in laser-plasma interaction with double-layer targets

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When an ultra-intense (>10^{18} W/cm^2) laser pulse interacts with a suitable target in the plasma state, relativistic electrons are accelerated. These electrons can emit high-energy photons (keV-MeV energy range) mainly through bremsstrahlung [1,2], mediated by the atoms and ions inside the target, and through synchrotron-like emission [3]. These emission processes can be exploited for diagnostics in experiments and for developing laser-based high-energy photon sources. These sources could complement conventional ones by providing unique properties like compactness, ultrafast duration, small source size, high energy and high flux. Advanced targets, like a double-layer target (DLT), can enhance the number and energy of relativistic electrons produced in the interaction and consequently boost emission. Specifically, a DLT is made of a solid substrate covered with a low-density layer which favours the laser-plasma coupling [4]. This contribution presents the results of numerical simulations investigating, in particular, bremsstrahlung in laser interaction with DLTs. The modelling of this atomic emission process in laser-plasma interaction needs proper investigation and discussion of the cross-section choice and use. Indeed, particle-in-cell codes, widely used tools to study laser-plasma interaction, can be coupled in different ways with Monte Carlo approaches [5,6] to simulate bremsstrahlung. After considering the rationale and criticalities of some of these simulation approaches based on open-source codes, we use these tools with the support of analytical models to study the leading processes and properties of bremsstrahlung in DLTs [7]. We look at the impact of the DLT and laser parameters on the emission properties. We also consider the competition with synchrotron-like emission and the effect of including other atomic processes, like target ionization, in the simulations. Our 2D and 3D simulations show how DLTs can enhance the number of high-energy emitted photons and tune emission according to their properties (thickness, density, atomic number). These results make bremsstrahlung in DLTs worthy of investigation in future experimental campaigns and potential applications like photon activation analysis [8] and laser-driven tomography.

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Presenting Author

Marta Galbiati

Presenting Author Affiliation

Department of Energy, Politecnico di Milano

Presenting Author Gender

Female

Country

Italy

Presenting Author Email Address

marta.galbiati@polimi.it

Primary author: Ms GALBIATI, Marta (Department of Energy, Politecnico di Milano)

Co-authors: Dr FORMENTI, Arianna (Department of Energy, Politecnico di Milano); Dr MIRANI, Francesco (Department of Energy, Politecnico di Milano); Dr MAFFINI, Alessandro (Department of Energy, Politecnico di Milano); Prof. PASSONI, Matteo (Department of Energy, Politecnico di Milano)

Presenter: Ms GALBIATI, Marta (Department of Energy, Politecnico di Milano)

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