Synchrotron emission from nanowire-array targets irradiated by ultraintense laser pulses

B. Martinez[1,2], E. d'Humières[2], L. Gremillet[1]

[1] *CEA, DAM, DIF, F-91297 Arpajon, France*

[2] *CELIA, UMR 5107, Université de Bordeaux-CNRS-CEA, 33405 Talence, France*

Forthcoming multi-petawatt lasers will enable scientists to access a new regime of laser-plasma interactions where collective plasma processes are intertwined with radiative and quantum electrodynamics effects, offering exciting prospects for fundamental and applied research [1, 2, 3, 4]. One underlying mechanism common to all these applications is the copious generation of hard x-ray or γ-ray photons through synchrotron emission–equivalent to nonlinear inverse Compton scattering in the strong-field regime.

Here we present the results of two-dimensional particle-in-cell simulations of the synchrotron emission from carbon nanowire arrays irradiated by femtosecond laser pulses of intensities $I = 10^{21} - 10^{23}\,\mathrm{Wcm}^{-2}$. The realization of intense laser-driven synchrotron sources is but the latest application of nanowire arrays, whose capability in strongly enhancing the laser energy absorption and hot-electron generation is now well established and exploited [5, 6]. Through an extensive parametric scan on the laser-target parameters, we identify and characterize several dominant radiation mechanisms, mainly depending on the transparency or opacity of the plasma produced by the laser-driven wire expansion, and on the quasistatic fields self-induced around the wires. At $I = 10^{22}\,\mathrm{Wcm}^{-2}$, the emission of high-energy ($> 10\,\mathrm{keV}$) photons attains a maximum energy conversion efficiency of $\sim 10\%$ for $\sim 30-50\,\mathrm{nm}$ wire widths and $1\,\mu\mathrm{m}$ interspacing. While this maximum radiation yield does not exceed that achieved in uniform plasma of same average (sub-solid) density, we show that nanowire arrays provide efficient radiation sources over a broader parameter range. Finally, we demonstrate that the radiation efficiency can be further boosted by adding a plasma mirror at the backside of the nanowire array.

References

[1] A. Di Piazza, C. Müller, K. Z. Hatsagortsyan, and C. H. Keitel, Rev. Mod. Phys. **84**, 1177 (2012).

[2] C. P. Ridgers *et al.*, Phys. Rev. Lett. **108**, 165006 (2012).

[3] L. L. Ji *et al.*, Phys. Rev. Lett. **112**, 145003 (2014).

[4] M. Lobet *et al.*, Phys. Rev. Lett. **115**, 215003 (2015).

[5] L. Cao *et al.*, Phys. Plasmas **17**, 043103 (2010).

[6] M. A. Purvis *et al.*, Nature Photon. **7**, 796 (2013).