Numerical modeling of injection of a relativistic electron bunch into a high intensity optical lattice

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Abstract

The X-rays free-electron lasers (XFEL), combine the unique properties of laser light with the atomic resolution and penetrating power of X-rays. The XFEL based on SASE (Self-Amplified Spontaneous Emission) process have a lot of new properties especially in terms of very short pulse duration (femtosecond) and focusability on very small spots, opening several new areas of research: single protein crystallography, strong field science in the X-rays, Warm Dense Matter, and even many medical applications, especially in oncology [1]. However, the current XFEL projects are so large, both in size and budget, that they are bound to remain Large Scale Infrastructures, with a real issue of beam-time availability, and will not have the possibility to disseminate in university-scale research centers, industrial laboratories, or hospitals[2].
Rapid progress in the development of high-intensity laser systems has extended our ability to study light–matter interactions far into the relativistic domain, in which electrons are driven to velocities close to the speed of light, thereby considerably reducing the size of particle accelerators[3]. Some authors have proposed applications intense optical lattice, through radiation by the electron oscillations in an optical potential, emissions in the far infrared for electrons initially at rest[4]; in the near infrared for non-relativistic electrons in motion [5]. We recently noted that an optical lattice in a strong field laser regime may create cases of completely original physics of laser / plasma interaction. We explore the particular case of interaction between relativistic electrons and optical lattice leading to: transverse trapping and guiding of electron beams; monochromatic betatron emission; Free Electron Laser by Raman effect [6], [7].
This poster shows how a compact XFEL can be constructed. I will show the trapping of relativistic electrons in the ponderomotive potential well of the optical lattice using Particle-In-Cell (PIC) simulation result of an injection code.

ARTICLE

[1] Emmanuel d'Humières and Philippe Balcou Compact XFEL Schemes (2009).
[2] Europeen XFEL http://www.xfel.eu/overview/how_does_it_work/
[3] V.Malka et al : 10,1038/nphys966 (2008).
[4] Sepke et al, Phys Rev. E 72, 026 501 (2005).
[5] Fedorov et al., Appl. Phys. Lett. 53, 353 (1988).
[6] Ph.Balcou Proposal for a Raman X-ray Free Electron Laser (2009).
[7] I.A Andriyash et al. 10.1103/PhysRevSTAB.16.100703