Relativistic electron dynamics in high intensity optical lattice. Towards a table-top Raman XFEL

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Abstracts: *A new scheme for an X-ray free electron laser is proposed, based on a Raman process occurring during the interaction between a relativistic bunch of free electrons issued from laser-plasma accelerated electrons, or from traditional Radio-Frequency LINACs, and twin intense short pulse lasers. I show the relativistic electron dynamics and the first experiment results in the high intensity regime of the Kapitza-Dirac effect.*

The quest for a compact X-rays laser has long been a major objective of laser science. Several schemes using optical ondulators are currently considered, in order to trigger the amplification of backscattered radiation, either in a Thomson or Compton regime. However, the practical conditions on the electron bunch parameters, in terms of mono-energeticity, emittance, divergence, and on those of the laser beams intensity constancy, are so stringent that no practical realization has yet been attempted. To overcome these limitations we have proposed a new concept of compact XFEL based on a combination between the physics of free electron lasers, of laser-plasma interactions, and of nonlinear optics [1]. This new scheme, the so called "Raman XFEL" is based on a Raman process occurring during the interaction between a moderately relativistic bunch of free electrons, and twin intense short pulse lasers interfering to form a transverse standing wave along the electron trajectories. The ponderomotive force can trap a relativistic electron bunch in the wells and results in transverse oscillations. This triggers a parametric process resulting in the emission of coherent radiation in the range of EUV or X-rays and the amplification of the Stokes component of the Raman-scattered radiation [1,2]. Analytical and numerical studies have demonstrated that very high gain values, with gain lengths in the sub-mm range, and high photon numbers can be expected [3]. In this talk we present a numerical study of the injection and trapping process of a bunch of relativistic free electrons into a transverse high intensity optical lattice, as required to achieve an all-optical Raman Free Electron Laser [3]. We unravel different injection regimes depending on the characteristic scale length of the onset of the optical lattice. We show some first experiment results obtained with the "Salle Jaune" laser at LOA, near Paris, of the interaction of a relativistic electron bunch issued from LWFA and an optical lattice. We will focus on the modification of the distribution function structures induced by the optical lattice and show some numerical modeling of LANEX diagnostics [3].

References:

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2) I. Andriyash, E. D'Humières, V. Tikhonchuk and Ph. Balcou, PRL 109, 244802.

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