Pulse splitting effects in short wavelength seeded free-electron lasers

Nicolas Joly[1], Marie Labat[2], Serge Bielawski[3], Christophe Szwaj[3], Christelle Bruni[4], & Marie-Emmanuelle Couprie[2]

[1] University of Erlangen Nuremberg, Günther-Scharowsky 1 / Bau 24. D-91058 Erlangen, Germany
[2] Synchrotron SOLEIL, Saint Aubin, BP 34, 91192 Gif-sur-Yvette, France
[3] PhLAM/CERLA, Bat. P5, Université des Sciences et Technologies de lille, 59655 Villeneuve d'Ascq, France
[4] Laboratoire de l'Accelerateur Lineaire, Orsay, France
nicolas.joly@physik.uni-erlangen.de

The present state of the art in electron accelerators allows to realize optical amplifiers in the VUV and X range, with very high gain. As a consequence, powerful emission can be obtained at very short wavelengths, using a single pass in the amplifier. To achieve temporal coherence of the output light, a strategy consists of injecting a low power coherent seed pulse from a classical (table-top) source. Experimental feasibility using harmonics generated in gases has been shown recently by part of the authors [1].

The way opened by these feasibility studies motivates systematic studies of the dynamics of the pulse propagation. In addition, the complexity of the experiments requires preliminary numerical and theoretical studies, before testing new setups, or operation in new conditions.

With this purpose, we present a theoretical and numerical study of the process, and show that a complex dynamics affects pulse propagation. In particular a pulse-splitting effect [2] is shown to affect propagation inside the FEL. We describe here the modeling of the effect and the numerical results. In particular, we use the FEL equations (the so-called Colson-Bonifaccio *FEL pendulum equations*) in an adimentional form in which relevant reduced parameters appear. Inspection of the reduced parameters should allow to anticipate the dynamical behavior of FELs prior to the design of new injection experiments.

[1] *Injection of harmonics generated in gas in a free-electron laser providing intense and coherent extreme-ultraviolet light*, G. Lambert, T. Hara, D. Garzella, T. Tanikawa, M. Labat, B. Carre, H. Kitamura, T. Shintake, M. Bougeard, S. Inoue, Y. Tanaka, P. Salieres, H. Merdji, O. Chubar, O. Gobert, K. Tahara, and M.-E. Couprie, Nature Physics **4**, 296 - 300 (2008)

[2] *Pulse splitting in short wavelength seeded Free Electron Lasers*, M. Labat, N. Joly, S. Bielawski, C. Szwaj, C. Bruni, and M. E. Couprie, Phys. Rev. Lett. 103, 264801 (2009)