

Reply to **Comment** on “Proposal for Raman X-ray free electron laser”

by Ph. Balcou, *Eur. Phys. J. D* **59**, 525–537 (2010)

Ph. Balcou^a

CELIA, Université de Bordeaux 1, 351 Cours de la libération, 33405 Talence Cedex, France

Received 19 January 2011 / Received in final form 8 February 2011
Published online 27 April 2011 – © EDP Sciences, Società Italiana di Fisica, Springer-Verlag 2011

Zholents and Zolotarev [1] are right to point out the crucial role of the magnetic field of the X-ray wave, which has not been adequately taken into account in the analytical derivations, and in the numerical calculations leading to Figure 5 of [2].

One effect is indeed to decrease by a $2\gamma^2$ factor the transverse Lorentz force of equation (15). However, it is then required to take into account all effects of the X-ray magnetic field; in particular, and as mentioned in [2], there is also a longitudinal Lorentz force, derived from the cross product of the y -oscillations induced by the external laser field, and of the X-ray magnetic field. This Lorentz force may induce electron bunching, very much as in the standard FEL case, but with a transverse dependence, and keeps a γ^{-1} functional dependence, as in equation (15).

The total effect of the X-ray magnetic field is therefore more subtle than anticipated, and it is not possible at this stage to conclude on the functional dependence in γ of the X-ray small signal gain in equation (37).

These effects need to be the object of a dedicated study, in the same theoretical framework as reference [2]; a completely different theoretical approach is also in preparation [3], dealing with the vector potential of the X-ray field instead of its electric and magnetic components, thus considering in a unified way the various Lorentz forces. Several other phenomena, such as X-ray beam diffraction and electron channeling, should also be taken into account.

I am grateful to A. Zholents and M. Zolotarev for their detailed attention to reference [2], making it possible to correct and improve this first theory of the raman X-ray free electron laser.

References

1. A. Zholents, M. Zolotarev, *Eur. Phys. J. D* (2011) DOI: 10.1140/epjd/e2011-10511-0
2. Ph. Balcou, *Eur. Phys. J. D* **59**, 525 (2010)
3. I. Andriyash, Ph. Balcou, V.T. Tikhonchuk, to be published

^a e-mail: balcou@celia.u-bordeaux1.fr