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Addendum to the article „On Harmonic Generation in X-Ray Free-Electron Lasers with Variable Undulator Deflection Parameter“ (*2021, vol. 91, iss. 12. p. 1881–1894*)

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The plots of the theoretically calculated spectral lines for some free electron lasers (FELs) are presented and explained. The plots allow evaluation of the spectral line width rather than showing real shape of the radiation line.

Keywords: free electron laser, spectral line, spectral density of radiation.

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In paper [1] graphs in Fig. 1, *b*, 2, *b*, 4, *b* and 5, *b* shall be correctly understood. The blue (in the online version) oscillating line calculated by us theoretically and shown on these graphs does not represent the shape of the FEL spectral line, as one might think by mistake. Blue oscillating line gives the representation of the splitting and broadening of the spectral line of the radiation due to the finite width of the beam and the related betatron effects. In order to avoid misunderstanding of the obtained results, their misinterpretation and to clarify the meaning of the Figures in the paper, we present new Figures, where a thick blue (online version) envelope represents the FEL radiation linewidth calculated by us. In most cases, this broadening exceeds or is not inferior to the linewidth of FEL SASE with self-amplification of spontaneous radiation. In the updated Figures we shown the spectral density calculated

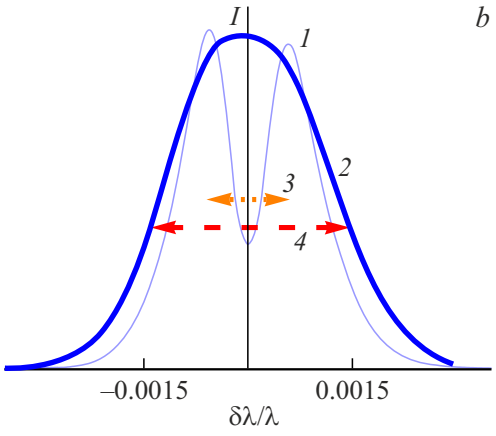

Fig. 1. *b* — spectra radiation density $\lambda = 11$ nm FEL FLASH 2 FEL FLASH2 with $E = 757$ MeV, $\sigma_e = 0.5$ MeV, $I_0 = 600$ A, $\gamma\varepsilon_{x,y} = 1.4$ mm × mrad. *1* — line splitting, *2* — envelope and estmate of spectrum linewidth, *3* — standard estimate of radiation linewidth SASE, *4* — experiment linewidth.

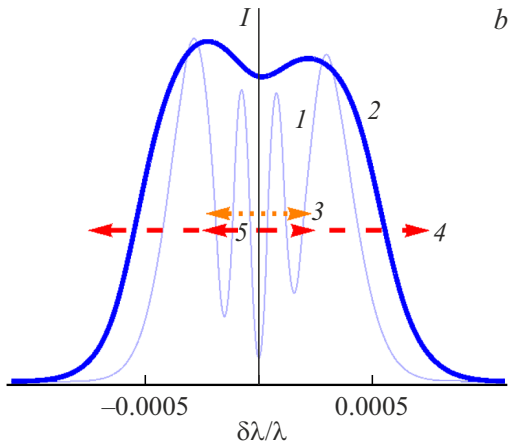

Fig. 2. *b* — spectral density of radiation $\lambda = 0.1$ nm FEL SwissFEL with $E = 5.8$ GeV, $I_0 = 2.0$ kA, $\sigma_e = 0.0125\%$, $\gamma\varepsilon_{x,y} = 0.2$ mm × mrad. *1* — line splitting, *2* — envelope and estiamte of spectrum linewidth, *3* — stamdard estimate of radiation linewidth SASE, *4* — maximum experiment width, *5* — minimum experiment linewidth.

by us in this way with a blue thick envelope, and the splitting inside it is shown with a thin blue line, as in the corresponding Figures in [1]. Note that the agreement with the experimentally measured values of the spectral density (red dashed line (in the online version) with arrows at the ends) for almost all FELs considered in this paper, as well as other main FELs operating worldwide, turns out to be significantly better for the theoretically calculated linewidth (thick blue envelope) than for the standard estimate of the linewidth SASE (orange line) corresponding to the spectral density $\delta\lambda/\lambda \approx \sqrt{\rho\lambda_u/L_s} \approx \rho$, where $\delta\lambda$ — linewidth, λ — FEL radiation wavelength, ρ — Pierce parameter, λ_u — undulator period, L_s — FEL saturation length.The author declares the support of the grant of the Ministry of Education and Science 075-15-2021-1353.

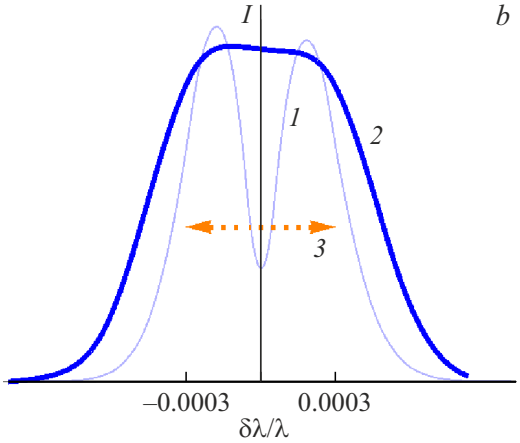

Fig. 4. *b* — spectral density of radiation $\lambda = 0.378$ nm FEL LCLS-II $E = 4$ GeV, $I_0 = 700$ A, $\sigma_e \approx 0.46$ MeV, $\gamma\varepsilon_{x,y} = 0.45$ mm × mrad. *1* — line splitting, *2* — envelope and estimate of spectrum linewidth, *3* — standard estimate of radiation linewidth SASE, no experiment data on linewidth.

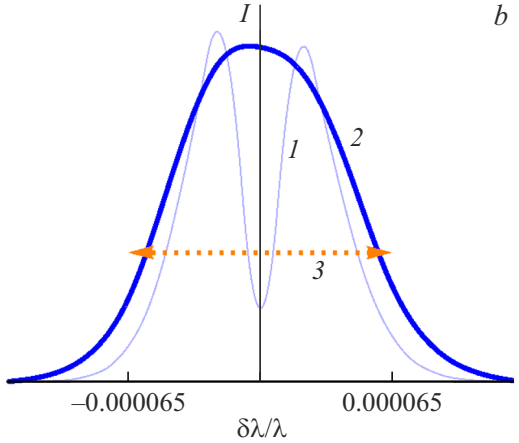

Fig. 5. *b* — spectral density of radiation $\lambda = 0.25$ nm FEL LCLS-II $E = 4$ GeV, $I_0 = 700$ A, $\sigma_e \approx 0.46$ MeV, $\gamma\varepsilon_{x,y} = 0.45$ mm × mrad. *1* — line splitting, *2* — envelope and estimate of spectrum linewidth, *3* — standard estimate of radiation linewidth SASE, no experiment data on linewidth.

References

[1] K. Zhukovskii. Tech. Phys., **67** (3), 221 (2022).

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