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Addendum to the article „Harmonics Generation in Experiments with Free-Electron Lasers in the X-Ray Wavelength Range: a Theoretical Analysis“ (*2021, vol. 91, iss. 3, p. 495–504*)

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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. 2, *b*, 5, *b*, 6, *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. The 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, which show a thick blue (online version) envelope, which 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.

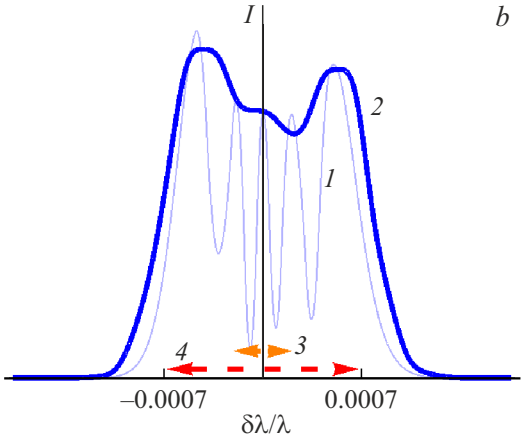

Fig. 2. *b* — spectral density of radiation $\lambda = 0.144$ nm FEL PAL-XFEL with $E = 8$ GeV, $\sigma_e = 0.18\%$, $I_0 = 27$ kA, $\gamma\varepsilon_{x,y} = 0.55$ mm × mrad. *1* — line splitting, *2* — envelope and spectral linewidth estimate, *3* — standard linewidth estimate SASE, *4* — experimental linewidth SASE for declared value $\delta\lambda/\lambda \approx 0.134\%$ [2].

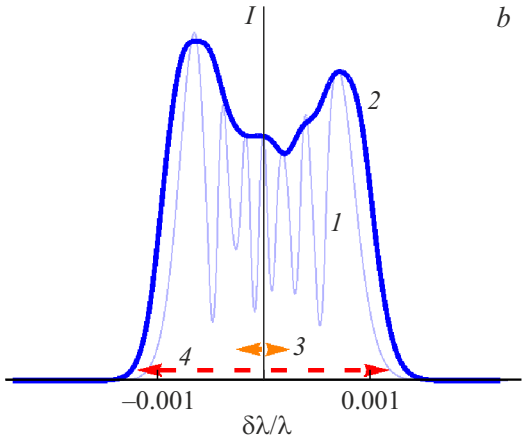

Fig. 5. *b* — spectral density of radiation $\lambda = 0.125$ nm FEL SACLA with $E = 7.8$ GeV, $\sigma_e = 0.0925\%$, $I_0 = 27$ kA, $\gamma\varepsilon_{x,y} = 0.6$ mm × mrad. *1* — line splitting, *2* — envelope and spectral linewidth estimate, *3* — standard linewidth estimate SASE, *4* — experimental linewidth SASE for declared value $\delta\lambda/\lambda \approx 0.03\%$ [3].

In the updated Figures we shown the spectral density calculated 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. For the FEL linewidth PAL-XFEL we

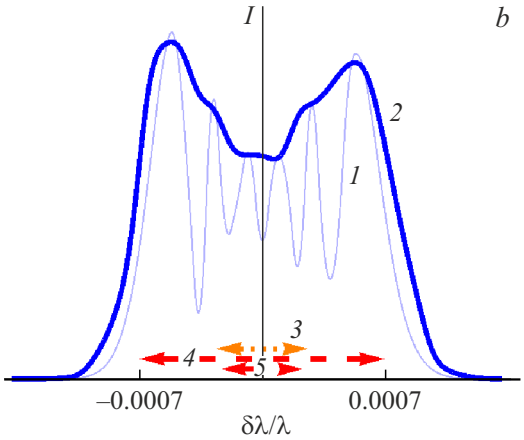

Fig. 6. *b* — spectral density of radiation $\lambda = 0.1\,\text{nm}$ FEL SwissFEL with $E = 5.8\,\text{GeV}$, $I_0 = 5.0\,\text{kA}$, $\sigma_e = 0.006\%$, $\gamma\varepsilon_{x,y} = 0.4\,\text{mm} \times \text{mrad}$. *1* — line splitting, *2* — envelope and spectral linewidth estimate, *3* — standard linewidth estimate SASE, *4* — maximum linewidth for declared experiment value $\delta\lambda/\lambda = 0.15\%$, *5* — minimum linewidth for declared experiment value $\delta\lambda/\lambda = 0.05\%$ [4].

used updated data from [2] with the measured spectral radiation density SASE $\delta\lambda/\lambda \approx 0.13\%$. Note that our theoretical results for the spectrum width, shown by the blue envelope in the Figures, are in excellent agreement with all experimental data (see [2–4] and other papers); (see red line in the Figures) as opposed to the standard estimate for the width SASE (orange line), which often turns out to be narrower than the actual measured values. The author declares the support of the grant of the Ministry of Education and Science 075-15-2021-1353.

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