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Analysis of laser-electron-radiation interaction in laser modulators for three SSMB scenarios

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Recent studies explored a novel storage ring light source using steady-state microbunching (SSMB). Existing investigations predominantly focused on single-particle and pure-optics phenomena. Many SSMB schemes employ laser modulators, comprising an undulator and copropagating laser beam, to manipulate electron longitudinal bunch length. Electron bunch traversing the undulator emits coherent undulator radiation near the resonant wavelength. Laser beams may form a closed path to become a laser enhancement cavity. We developed a model* analyzing laser-electron-radiation interactions in laser modulator cavities, considering mirror-induced losses, externally injected laser power compensation, and coherent undulator radiation dynamics on multiple turns. Our approach integrates beamline transfer matrices with a low-gain FEL oscillator model, enabling quick estimation of the dynamic effects. In this work we examine three SSMB scenarios, amplifier, frequency-beating, and harmonic, accounting for laser-electron-radiation interactions. Under preliminary design parameters, our analysis suggests feasibility for the three scenarios. A potential self-seeding SSMB scheme is also investigated.

Footnotes

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Region represented

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