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Characterization of Coherent Seeded FEL Pulses in the Presence of Incoherent Electron Beam Energy Modulations

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Over the last few years tremendous progress has been gained in the theoretical understanding and experimental demonstration of seeded FELs. The ultimate spectral limit of seeded FEL, however, remains unclear, because of the broadening and distortions induced in the output spectrum by residual broadband energy modulations in the electron beam.

In this talk, we present the mathematical descriptions of the impact of broadband energy modulations on the EEHG, HGHG and self seeding bunching spectrums produced by the microbunching instability through both the accelerator and the FEL line. We will show the agreement of our models with the systematic experimental characterization seeded FEL spectrums in FERMI and Eu-XFEL. Using experimental data of EEHG FEL performance in FERMI in the photon energy range 130–210 eV, we demonstrate that amplification of electron beam energy distortions primarily in the EEHG dispersive sections explains an observed reduction of the FEL spectral brightness proportional to the EEHG harmonic number. Local maxima of the FEL spectral brightness and of the spectral stability are found for a suitable balance of the dispersive sections' strength and the first seed laser pulse energy[1].

[1] Physical Review Accelerators and Beams 24, 8, 2021

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Primary author: MIRIAN, Najmeh (Deutsches Elektronen-Synchrotron)

Co-authors: DE NINNO, Giovanni (Elettra-Sincrotrone Trieste S.C.p.A.); PEROSA, Giovanni (University of Trieste, Elettra Sincrotrone Trieste); GIANNESI, Luca (Elettra Sincrotrone Trieste and Istituto Nazionale di Fisica Nucleare); DI MITRI, Simone (Elettra-Sincrotrone Trieste S.C.p.A.); ALLARIA, Enrico (Elettra-Sincrotrone Trieste S.C.p.A.); Dr REBERNIK, Primož (Elettra-Sincrotrone Trieste S.C.p.A.)

Presenter: MIRIAN, Najmeh (Deutsches Elektronen-Synchrotron)

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