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Fast modeling of regenerative amplifier free-electron lasers

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The regenerative amplifier FEL (RAFEL) promises to greatly increase the brightness and stability of single pass x-ray FELs. One of the critical challenges of the x-ray RAFEL is maintaining electron-optical overlap over the relatively large (hundreds of meters) footprint of the system. Numerical modeling of x-ray RAFELs with angular and positional errors is critical for designing stable cavities, as well as to predict signatures of specific misalignment effects. Full-scale simulations of x-ray FELs are incredibly time consuming, making large-scale parameter searches intractable on reasonable timescales. We present a semi-analytical model that allows to investigate realistic scenarios - x-ray cavity without gain ("cold cavity"or x-ray FEL oscillator) and x-ray RAFEL in the presence of angular/positional errors and electron trajectory oscillation. We especially focus on fast modeling of the FEL process and x-ray optics, while capturing effects pertaining to actual experimental setups at the Linac Coherent Light Source (LCLS) at SLAC. Such a method can be used to explore RAFEL at other wavelengths by suitable replacement of the optics modeling.

Footnotes

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Primary author: ROBLES, River (Stanford University)

Co-authors: Dr HALAVANAU, Aliaksei (SLAC National Accelerator Laboratory); MARCUS, Gabriel (SLAC National Accelerator Laboratory); HUANG, Zhirong (SLAC National Accelerator Laboratory)

Presenter: ROBLES, River (Stanford University)

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