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## On the spontaneous emission in quantum free-electron lasers

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In this work, we investigate the spontaneous emission process and its detrimental effects on coherent free-electron laser (FEL) emission. In our model, the electron dynamics are described by a discrete Wigner distribution coupled to Maxwell equations. For an FEL operating in the quantum regime of single photon recoil, insights on the variation of momentum distribution, bunching factor, and radiation power are presented. We also derive a simple differential equation that describes the evolution of the radiated power in the linear regime. It is shown that the essential results of this work agree with those predicted by a density matrix approach.

**Primary author:** FARES, Hesham

**Co-authors:** ROBB, Gordon R. M. (University of Strathclyde); PIOVELLA, Nicola (MI)

**Presenter:** FARES, Hesham

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