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Space charge effects on density-modulated electron beams in drift spaces

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Seeding of free-electron lasers (FELs) is based on a periodic modulation of the electron energy by an external radiation pulse converted to a density modulation in a dispersive section. In complex configurations such as cascaded high-gain harmonic generation (HG) or echo-enabled harmonic generation (EEHG), the density-modulated electron beam may need to be propagated through drift spaces or detuned undulators before starting the lasing process in the FEL undulator (the “radiator”). In such a case, space charge tends to smear out the maxima of the electron density but also reduces the energy spread of the electrons between them. Studies on the evolution of the density-modulated beam in drift spaces and detuned undulators were carried out in different configurations of the FEL-1 beamline of FERMI, the FEL user facility at Elettra Sincrotrone Trieste in Italy. The paper compares the experimental findings on FEL emission after propagating the electron bunches with and without density modulation with simulation predictions and analytical estimates.

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