FEL COHERENCE BELOW SHOT NOISE LIMIT, AND ITS FUNDAMENTAL LIMITS

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Abstract

SASE X-UV Free Electron Lasers (FEL) operate as noise amplifiers. They are spatially coherent, and extremely bright, but not temporally coherent. Pre-bunching scheme, such as HGHG, and seed radiation injection schemes (HHG) make it possible to attain, in principle, fully coherent FELs, which would have also extremely high spectral brightness. To achieve this goal, the coherently amplified FEL power must be significantly higher than the SASE power, which in this case is just an undesirable noise. An alternative way, suggested here, is to provide a scheme for reducing the SASE input power, namely the shot noise, by a scheme of current fluctuation smoothing, based on controlled e-beam (Langmuir) plasma wave oscillation in non-radiating sections along the accelerator and FEL e-beam transport line. This will permit to achieve full laser coherence with lower seeding power than required presently, and can provide a significant short-cut to achieving coherent FEL radiation in the X-UV regime. We further derive the theoretical limits for the coherence of noise-reduced FEL amplifiers, and find that it is ultimately limited only by quantum noise.

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