A proposal for a mode-locked hard x-ray free-electron laser

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Mode-locking in a free-electron laser (FEL) modifies the FEL output, resulting in an x-ray frequency comb comprised of a large number of frequency lines in the spectral domain, and a sequence of ultra-short x-ray micro-pulses with a fixed and well-defined temporal separation in the time domain. First proposed by Thompson and McNeil [1], the idea of FEL mode-locking quickly attracted the attention of scientists and FEL designers [2, 3]. In this paper we propose a new approach that seems to be easier to implement, and can possibly be employed at the LCLS with few modifications. The first part of the new scheme relies on modulating the FEL gain by introducing a modulation in the peak electron beam current, which can be achieved in a very similar way as that proposed for Enhanced Self-Amplified Spontaneous Emission [4]. The second part of the scheme utilizes the idea of hard x-ray self-seeding [5, 6], in which the x-ray light produced by the electron bunch in the first FEL is used to provide a monochromatic seed for operation of the downstream FEL after passing through a diamond monochromator. In this case, a sequence of electron micro-bunches produces the light required for the monochromatic seed field which, when amplified by the same electron micro-bunches in the downstream undulator, results in a phase-locked x-ray pulse train with the output characteristics comparable to that of a mode-locked laser.

References

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