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Recent Advances in X-Ray Free Electron Lasers[1]

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X-ray free electron lasers(FELs) are undergoing an exciting development. They will soon become a reality with the commissioning of the LCLS in early next year, soon followed by Spring 8 X-FEL and the European XFEL at Hamburg. Intense, coherent pulses of x-rays from these machines will permit exploration of the atomic world with spatial and temporal precisions hitherto not feasible. After these first generation x-ray FELs based on self-amplified spontaneous emission (SASE) in a single pass high-gain system, the next generation devices for higher performance and/or smaller and lower cost are under various stages of development. In the soft x-ray region, seeded FELs with high harmonic generated (HHG) laser input will produce coherent output in a shorter system. Drastic improvement in hard x-ray region is possible with new types of electron injectors producing electron beams with an order of magnitude smaller emittance. Hard x-ray FELs can be built with an order of magnitude smaller electron energy and thus with a significant savings in the cost. The Spring-8 FEL is a first step in this direction. Novel types of FELs are possible; ultra-short SASE providing sub-fs time-resolution and x-ray FEL oscillator (XFELO) providing ultra-narrow spectral resolution. The XFELO employs optical cavity formed by Bragg reflectors, delivering temporally and spatially coherent hard x-rays, with meV spectral resolution. Its peak spectral brightness is similar to but the average spectral brightness is about five orders of magnitudes higher than LCLS.

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