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Compact X-ray Free-electron Laser with Nano-patterned Electron Beams

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We are pursuing development of a very compact XFEL based on inverse Compton scattering (ICS) from a nanopatterned electron beam. CXFEL depends on a novel method to produce transform-limited x-ray output in all dimensions, i.e., with all photons in a single degenerate quantum state. This method avoids the noise amplification of SASE by imprinting a well-defined coherent modulation on the electrons via diffraction in a thin crystal grating. We will present experimental results demonstrating the first steps in this method. The spatial pattern in the diffracted electrons is converted to a temporal pattern using sophisticated electron optics that exchange the transverse and temporal phase space dimensions. The result is a nano-patterned electron beam that can be tuned for wide range of applications. The method allows for coherent control of the phase, frequency, bandwidth, pulse length and amplitude of the x-ray pulses, and enables a variety of multi-color experiments with precisely tunable femtosecond delays for pump-probe experiments, and perhaps even sub-cycle phase-locking of the multiple colors. The output will cover the photon energy range from 100 eV to 8 keV. The CXFEL pulse energy is expected to be tens of nJ due to its small size and low beam energy. For experiments that require higher pulse energies or harder photons, CXFEL presents an excellent seed source that can transfer its unique phase control to large XFELs.