Recent Developments at LCLS and Science Opportunities and Plans for LCLS-II and LCLS-II-HE

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The unique capabilities of LCLS, the world's first hard X-ray FEL, have had significant impact on advancing our understanding across a broad range of science, from fundamental atomic and molecular physics, to condensed matter, to catalysis, to structural biology.

A major upgrade of the LCLS facility (LCLS-II project) is now underway. LCLS-II is being developed as a high-repetition rate X-ray laser with two simultaneously operating, independently tunable FELs. The baseline design features a 4 GeV continuous wave superconducting linac (CW-SCRF) that is capable of producing uniformly spaced (or programmable) ultrafast X-ray laser pulses at a repetition rate up to ~1 MHz spanning the energy range from 0.25 to 5 keV. The superconducting linac is now being installed in the first third of the SLAC linac tunnel. The final third of the SLAC linac will continue to operate as a warm Cu accelerator at energies up to 15 GeV, providing tunable X-rays with photon energy up to 25 keV at 120 Hz. Four new instruments are planned to exploit the new capabilities of LCLS-II. One instrument will support AMO science, strong-field science, and a new dynamic reaction microscope. Two instruments will rely on a monochromator to support high-resolution and moderate-resolution soft X-ray spectroscopy at close to the Fourier transform limit. A fourth instrument will operate in the tender X-ray range (1-7 keV) and will be capable of combining pulses from both the soft X-ray and hard X-ray FELs.

Looking to the future, there is a compelling opportunity to upgrade the energy of LCLS-II (LCLS-II-HE). By adding CW-SCRF cryomodules, the electron beam energy can be doubled to 8 GeV, thus increasing the spectral reach of the hard X-ray undulator (HXU) to more than 12 keV. Anticipated improvements in electron beam emittance will extend the energy reach to 20 keV. This will enable the study of atomic-scale dynamics with the penetrating power and pulse structure needed for *in situ* and *operando* time-resolved studies of real-world materials, functioning assemblies, and biological systems.

This talk will present some of the important science opportunities, new capabilities and instrumentation being planned for LCSL-II and LCLS-II-HE.

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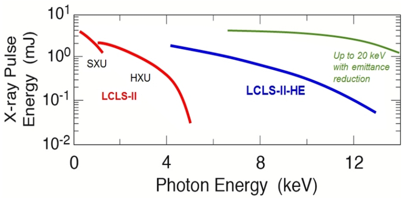

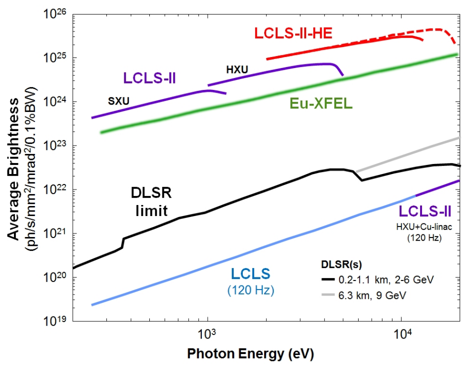

Calculated energy per pulse (left) and average brightness (right) for LCLS-II and proposed LCLS-II-HE, including future X-ray facilities: the European XFEL and diffraction-limited storage rings (DLSRs).