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Cascaded Amplification of Attosecond X-Ray Pulses: Towards TW-Scale Ultrafast X-Ray Free-Electron Lasers

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The natural time scale of valence electronic motion in molecular systems is on the order of hundreds of attoseconds. Consequently, the time-resolved study of electronic dynamics requires a source of sub-femtosecond pulses. Pulses in the soft x-ray domain can access core-level electrons, enabling the study of site-specific electron dynamics through attosecond pump/probe experiments. As time-resolved pump/probe experiments are nonlinear processes, these experiments require high brightness attosecond x-ray pulses. The X-ray Laser-Enhanced Attosecond Pulses (XLEAP) collaboration is an ongoing project for the development of attosecond x-ray modes at the Linac Coherent Light Source (LCLS). Here we report development of a high power attosecond mode via cascaded amplification of the x-ray pulse. We experimentally demonstrate generation of sub-femtosecond duration soft x-ray free electron laser pulses with hundreds of microjoules of energy. In conjunction with the upcoming high repetition rate at LCLS-II, these tunable, high intensity attosecond capabilities enable new nonlinear spectroscopic techniques and advanced imaging methods.

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Primary authors: FRANZ, Paris (Stanford University); MARINELLI, Agostino (SLAC National Accelerator Laboratory); GUO, Zhaoheng (Stanford University); ROBLES, River (Stanford University); BOHLER, Dorian (SLAC National Accelerator Laboratory); CESAR, David (SLAC National Accelerator Laboratory); CHENG, Xinxin (SLAC National Accelerator Laboratory); DRIVER, Taran (SLAC National Accelerator Laboratory); DURIS, Joseph (SLAC National Accelerator Laboratory); KAMALOV, Andrei (SLAC National Accelerator Laboratory); LI, Siqi (SLAC National Accelerator Laboratory); OBAID, Razib (SLAC National Accelerator Laboratory); SUDAR, Nick (SLAC National Accelerator Laboratory); WANG, Anna (SLAC National Accelerator Laboratory); ZHANG, Zhen (SLAC National Accelerator Laboratory); CRYAN, James (SLAC National Accelerator Laboratory)

Presenters: FRANZ, Paris (Stanford University); GUO, Zhaoheng (Stanford University); ROBLES, River (Stanford University); BOHLER, Dorian (SLAC National Accelerator Laboratory); CESAR, David (SLAC National Accelerator Laboratory); CHENG, Xinxin (SLAC National Accelerator Laboratory); DRIVER, Taran (SLAC National Accelerator Laboratory); DURIS, Joseph (SLAC National Accelerator Laboratory); KAMALOV, Andrei (SLAC National Accelerator Laboratory); LI, Siqi (SLAC National Accelerator Laboratory); OBAID, Razib (SLAC National Accelerator Laboratory); SUDAR, Nick (SLAC National Accelerator Laboratory); WANG, Anna (SLAC National Accelerator Laboratory); ZHANG, Zhen (SLAC National Accelerator Laboratory); CRYAN, James (SLAC National Accelerator Laboratory)

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