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Ultrafast science using Laser Wakefield Accelerators[1]

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Recent progress in laser wakefield acceleration has led to the emergence of a new generation of electron and X-ray sources that may have considerable benefits for ultrafast science. Laser wakefield acceleration provides radiation pulses that have femtosecond duration and intrinsic synchronisation with the laser source, allowing for pump-probe measurements with unprecedented temporal resolution. These pulses can be used to study ultrafast dynamical phenomena in plasma and dense material, such as transient magnetic fields, rapidly evolving plasma dynamics and crystal lattice oscillations. In this talk, I will review recent experiments in laser wakefieldacceleration and energetic photon generation using the laser systems HERCULES and Lambda-Cubed at the University of Michigan and their use for capturing the dynamics of laser-pumped samples. Studies of theelectron beam hosing instability and the generation ofannular phase space distributions increase X-ray flux while maintaining its femtosecond duration. Single-shot, spectrally resolved absorption measurements in laser pumped foils can be made on ultrafast timescales using this broadband photon source. Ultrafast electron radiography is able to temporally resolve relativistically expanding magnetic fields in high-intensity laser-solid interactions and the evolution of electric fields in low density plasma.Time-resolved electron diffraction captures structural dynamics in crystalline silicon. I will also discuss the technological needs for and potential impact of such revolutionary compact radiation sources for ultrafast science in the future.

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