Ultra-relativistic Electron Acceleration by a High-power Ultrafast Laser

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Diocles, a recently commissioned laser system at the University of Nebraska, Lincoln (UNL) has demonstrated exceptional performance characteristics, including 30-fs pulse duration, 100-TW peak power, diffraction-limited focusing, and energy stability of only a few percent. In initial experiments, the laser was used as the driver for a wakefield accelerator, to accelerate a beam of electrons to energies up to 0.8 GeV, with angular divergence of < 2-mrad. In this case, a high-intensity laser pulse (> 1019 W/cm^2) was relativistically self-guided through plasma a distance > 5mm, corresponding to over 8 Rayleigh ranges. When these electrons underwent betatron oscillations in the plasma channel, a beam of hard x-rays, with fs pulse duration, was also generated. We will discuss the laser's architecture and performance, as well as plans to upgrade it to the petawatt peak power level. Details of the experiments and a comparison of their results to theory and simulation will also be presented.