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Efficient Extreme Light Compression and its Application

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High power laser facilities capable of generating petawatt (10^{15} W) level pulses are producing peak intensities that are approaching the threshold to a wide range of applications that include high energy physics; laser astrophysics and cosmology; vacuum physics; as well as medical imaging and treatments. State-of-the-art in high power laser systems consistently produce pulses within large diameter beams with nearly flat-top spatial modes and low divergences that suggest efficient nonlinear techniques for pulse post-compression that could dramatically extend the intensities achievable within existing facilities. Theoretical simulations demonstrate the potential for such a system and the efficiency of the process presents a route to compress the high power laser toward its wavelength-defined fundamental limit of a few femtoseconds while maintaining Joule-level energy within the pulse. At present, small-scale experimental tests of the methods involving the cooperative efforts of many research partners are demonstrating the conditions required to implement a full-scale test of the process while providing insight on the challenges that will arise. In addition, such high energy, single-cycle pulses show great promise as drivers of secondary sources for improved laser-driven ion acceleration, as well as hard X-ray pulses from solid targets capable of producing atto/zeptosecond-scale pulses at the exawatt level (10^{18} W).

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