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Prospective methods for generating sub-picosecond long-wave infrared lasers for advanced accelerators

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The λ^2 scaling of the ponderomotive force underpinning laser-based particle accelerators encourages the use of long wavelengths in regimes such as laser wakefield acceleration of electrons at low plasma densities. High pressure CO_2 amplifiers are the workhorse source of such lasers, able to achieve multi-TW peak powers and picosecond pulse lengths. We are developing wavelength conversion techniques utilizing stimulated Raman scattering, where the energy of a photon is modified by inelastically scattering with a coherent excited state of a material, employing calcite to generate the 9.2 μm seed, and ionic liquids, artificial salts that are liquid at room temperature, for the 4.3 μm pump. Additionally, we are examining the use of self phase modulation to broaden the spectrum after the amplifier, followed by chirp compensation/compression. Together, we anticipate that these techniques will generate 25 TW, 100 fs LWIR pulses, which have been shown in simulation to enable new regimes in laser wakefield acceleration, such as the blowout regime of laser wakefield accelerators with millimeter-scale plasma structures.

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