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Enabling Technologies for Next-Generation M/L-WIR Lasers

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The advanced accelerator community increasingly recognizes the importance of extending high peak- and average-power laser facilities to longer wavelengths. This recognition is driven by the lambda-squared scaling of the ponderomotive force, inverse-lambda-squared scaling of critical plasma density, and linear-lambda scaling of the number of photons per joule of energy. A significant potential application of long-wave infrared (L-WIR) lasers is in laser wakefield acceleration (LWFA), where achieving an efficient "bubble" acceleration regime is expected at pulse durations below 1 ps and peak powers exceeding 10 TW.

Currently, picosecond pulse amplification in high-pressure-gas CO2 amplifiers is the only method capable of generating L-WIR pulses with terawatt energies and beyond. Nevertheless, emerging mid- and long-wave infrared (M/L-WIR) solid-state laser technologies are essential for providing the necessary infrastructure for next-generation systems. For instance, multi-millijoule solid-state seed lasers can enable the generation of ~500 fs multi-joule pulses at the output of chirped-pulse amplification-based CO2 amplifiers. Additionally, high-energy lasers at 2.8 μm are required for the efficient pumping of CO2 amplifiers at high repetition rates.

In this talk, we present an overview of the current state of L-WIR lasers relevant to LWFA, emphasizing the latest trends in the development of supporting M/L-WIR laser systems and their components. This includes advancements in multi-millijoule seed lasers and high-energy pump lasers, which are critical for achieving the next generation of high-power, high-repetition-rate laser systems. These developments are crucial for enabling new capabilities and enhancing the performance of LWFA, driving progress in the field of advanced accelerators.

Working group

WG1 : Laser-driven plasma wakefield acceleration

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