Optimizing PW Laser-Driven Proton Acceleration by Characterizing Laser Transmission of Relativistically Transparent Targets

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Ion acceleration by compact laser-plasma sources has great potential for a range of applications, including those with medical relevance and fusion experiments. However, in order to achieve the necessary beam quality parameters for these applications, a thorough understanding and control over the laser-plasma interaction process is required.

Therefore, we are exploring laser plasma acceleration around the promising regime of Relativistically Induced Transparency (RIT) through joint studies at DRACO PW (HZDR) and the J-KAREN-P laser system at KPSI. We have performed thickness scans to investigate the relation between proton acceleration performance and target transparency, revealing high-performance proton beams (> 60 MeV) in an expanded foil case, with an optimum at the onset of target transparency. [1] Subsequent experiments showed even higher proton energies.

Clearly, the relationship between the transparency onset time and the acceleration performance is crucial for achieving optimal beam parameters, improving our understanding of the sensitivity of laser input parameters, and increasing the process's robustness. Thus, we are using a combination of particle and laser diagnostics to investigate this correlation.

In this contribution, we present a summary of our studies in which we use spectral interferometry with the unperturbed laser beam as a reference to evaluate the output of reflected and transmitted light diagnostics. Obtaining features like shown in Bagnoud *et al.* [2] and Williamson *et al.* [3], we additionally correlate these measures with the proton acceleration performance and show first results of spectral, spatial, and energy analysis of the effects on the laser transmission through the target.

References

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