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Characterizing Laser Transmission in the Relativistically Induced Transparency Regime for PW Laser-Driven Proton Acceleration

Ion acceleration via compact laser-plasma sources presents great potential for applications ranging from medical treatments to fusion research. Achieving the desired beam quality parameters necessitates an in-depth understanding and precise control of the laser-plasma interaction process. Our ongoing collaborative research at the DRACO PW (HZDR) and J-KAREN-P (KPSI) laser systems is focused on investigating the promising regime of Relativistically Induced Transparency (RIT).
In prior studies [1], we achieved high-performance proton beams (>60 MeV) in an expanded foil configuration, identifying an optimum at the onset of target transparency. Subsequent experiments recorded proton energies exceeding 100 MeV [2], emphasizing the critical role of the transparency onset time in optimizing beam parameters and enhancing process robustness. We utilize a combination of particle and laser diagnostics to explore the correlation between transparency onset and acceleration performance.
This contribution details our recent investigations into spectral components of transmission and emission from the laser-plasma interaction along the laser axis. Building upon established methodologies [3], our approach involves spectral interferometry, using the unperturbed laser beam as a reference, and correlates findings with proton acceleration performance. Our results indicate a promising direction for focused analysis of spectral and spatial light distribution, providing deeper insights into the complexities of laser-plasma interactions. They suggest multiple contributions to the transmission mechanisms, potentially involving a multi-shuttering process.

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[1] Dover, N.P. et al.: Light Sci. Appl. (2023).
[2] Ziegler, T. et al.: Nat. Phys. (2024).
[3] Williamson, S.D.R. et al.: Phys. Rev. Appl. (2020).

Working group

WG2 : Laser-driven plasma acceleration of ions

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