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

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Ion acceleration through compact laser-plasma sources holds great potential for diverse applications, from medical treatments to fusion experiments. Achieving the required beam quality parameters demands a deep understanding and precise control of the laser-plasma interaction process. Our ongoing collaborative research at DRACO PW (HZDR) and J-KAREN-P (KPSI) laser systems focuses on exploring the promising regime of Relativistically Induced Transparency (RIT).

In previous studies [1], we observed high-performance proton beams (>60 MeV) in an expanded foil case, showcasing an optimum at the onset of target transparency. Subsequent experiments revealed even higher proton energies beyond 100 MeV [2], emphasizing the important role of the transparency onset time in optimizing beam parameters and enhancing process robustness. We employ a combination of particle and laser diagnostics to explore the correlation between transparency onset and acceleration performance.

This contribution highlights our recent investigations into spectral and spatial components of transmission and emission arising from the laser-plasma interaction. Building upon established methodologies [3,4], our approach involves spectral interferometry, using the unperturbed laser beam as a reference, and correlating findings with proton acceleration performance. Our results suggest a promising avenue for a focused analysis of spectral and spatial distribution, offering additional insights into the complexities of the laser-plasma interaction process. By emphasizing these aspects, we aim to deepen our understanding of factors influencing ion acceleration, contributing to the optimization of beam quality parameters.

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