Laser Pulse Spectral Phase Effects on Target Normal Sheath Acceleration

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Motivation

In a recent study Tayaab et al. [1] investigated TNSA proton cut-off energy dependence on temporal characteristics of the laser pulse. By changing grating separation in their CPA laser-pulse compressor they found that a positively chirped pulse provides more energetic protons compared to a negatively chirped pulse of the same duration. However, grating compressors normally introduce higher order spectral phase which causes temporal assymetry of the pulse. Their conclusion was that it is the assymetry (longer leading edge of the pulse) that causes higher proton energy.

In the present study we measure and control also higher order phase and observe its effect on TNSA protons, thus disentangling laser pulse chirp and shape.

We study the effect by using ultra-high contrast pulses, provided by a double plasma mirror setup, with accurately controlled and shaped spectral phase utilizing an acousto-optic programmable dispersive filter (DAZZLER) and SPIDER as measurement device.

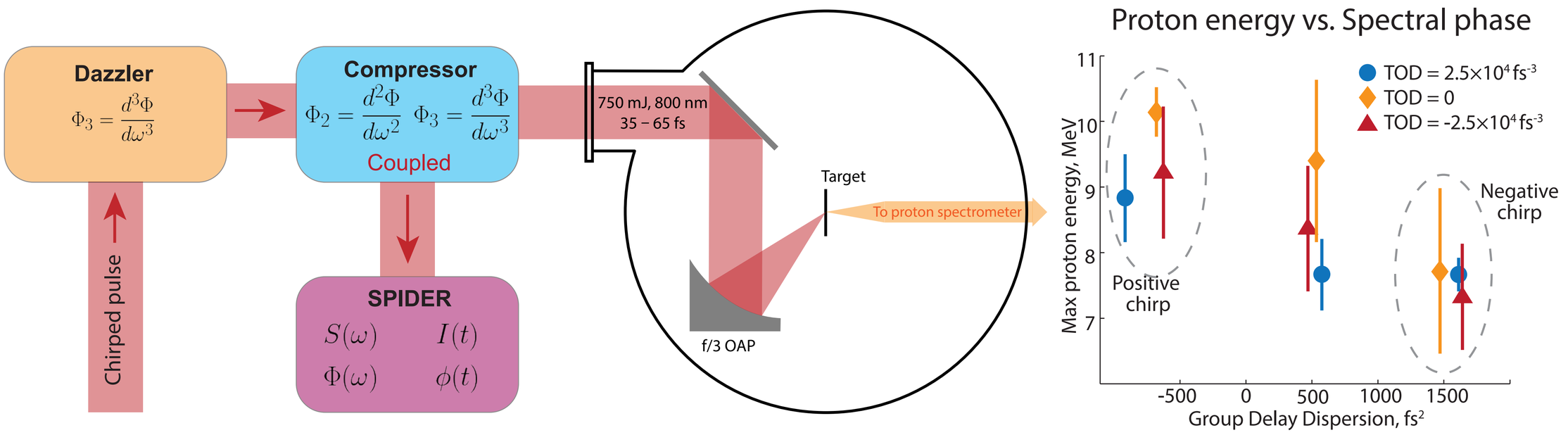
Spectral vs. Temporal

It is a lot more convenient to investigate ultrashort laser pulse properties in terms of spectral phase Taylor expansion coefficients instead of temporal properties. This study focuses on the effects of second-order spectral phase, also known as group delay dispersion (GDD) and third-order dispersion (TOD).

In temporal domain GDD is responsible for the chirp of the pulse, TOD is affecting the symmetry of the pulse shape.

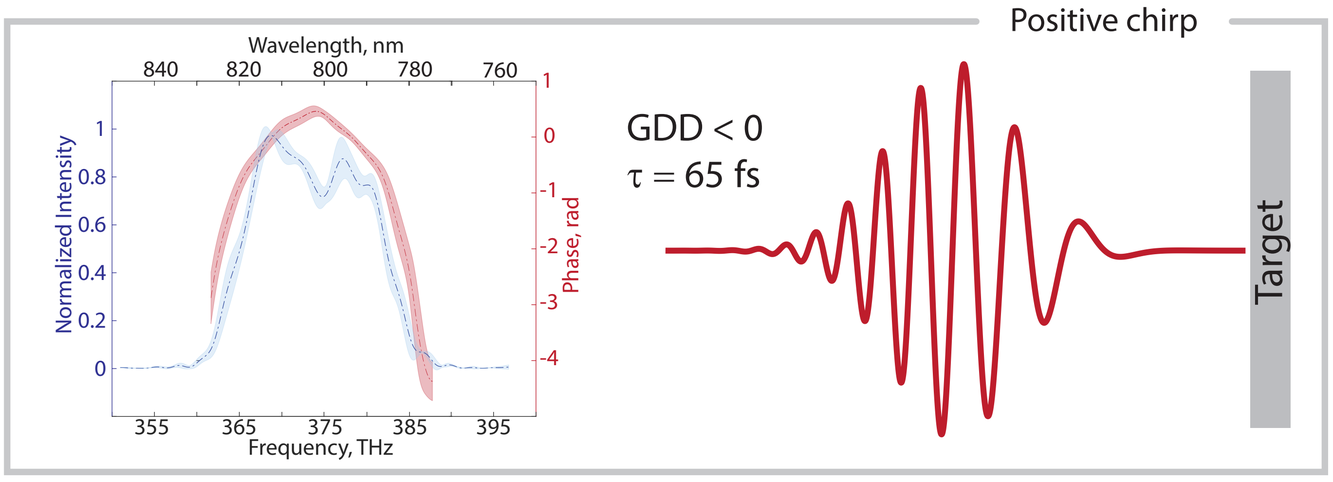
Usage of spectral phase allows easier characterization of the pulse.

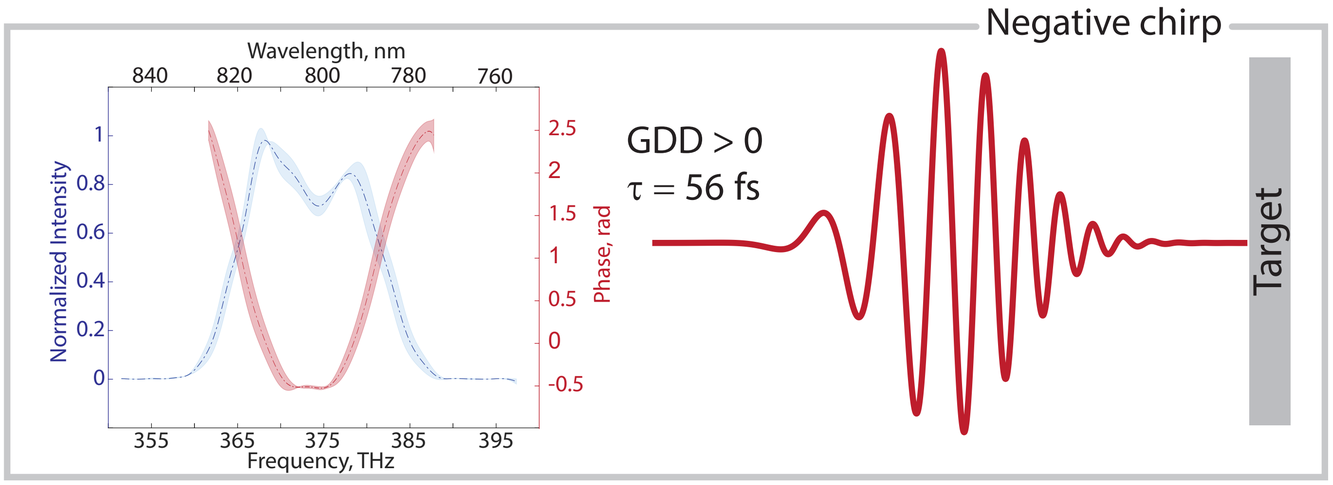
Effect of Spectral Phase

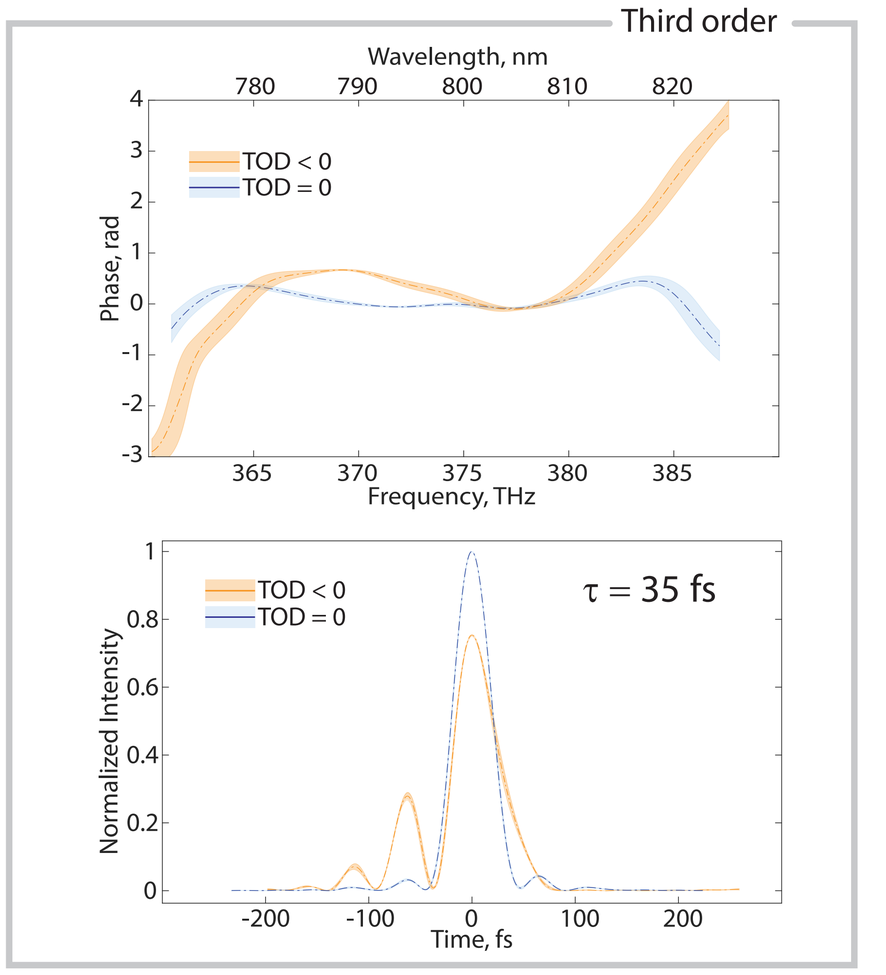


Positive chirp of the pulse gives higher proton energy compared to negatively chirped or transform limited pulse. TOD = 0 (symmetric pulse) results in highest proton energy for each pulse duration.

Spectral Phase and Temporal Shape Analysis







[1] Tayyab, M., et al. "Effect of temporally modified ultra-short laser pulses on ion acceleration from thin foil targets." Physics of Plasmas 25.8 (2018): 083113.

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