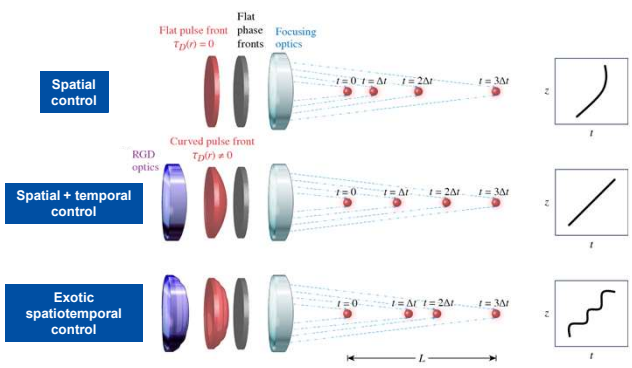
Programmable-trajectory ultrafast flying focus pulses

M. V. Ambat, J. L. Shaw, J. J. Pigeon, K. G. Miller, T. T. Simpson, D. H. Froula, and J. P. Palastro

University of Rochester, Laboratory for Laser Energetics

Introduction

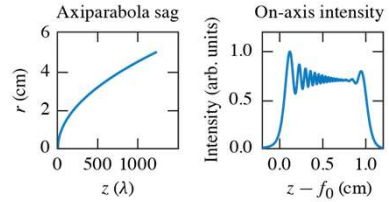
Flying focus pulses offer optimization of laser-based applications that require velocity matching or extended interaction[1-3] such as laser wakefield acceleration[4] and THz generation[5].



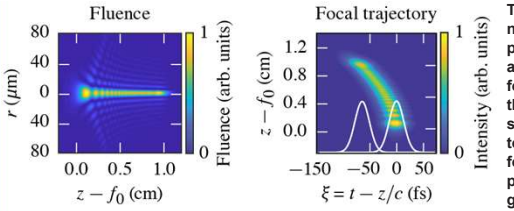
Ultrafast flying focus pulses require optics that produce an extended focal range.

By separately controlling the focal times via radial group delay, the focal trajectory can be controlled[6].

Advanced Optics for Spatial Control: Axiparabola

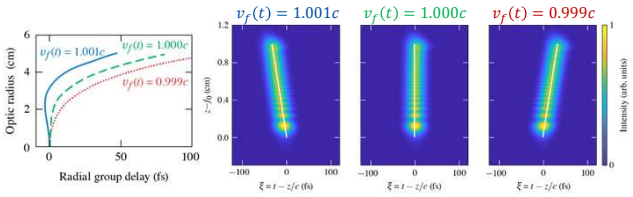


The axiparabola[7] is one optic that produces an extended focal range.



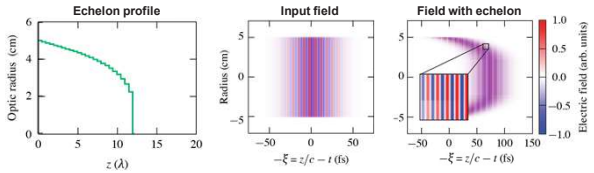
The axiparabola naturally produces an accelerating focal trajectory, thus requiring separate optics to control the focal time of the pulse via radial group delay.

Radial Group Delay



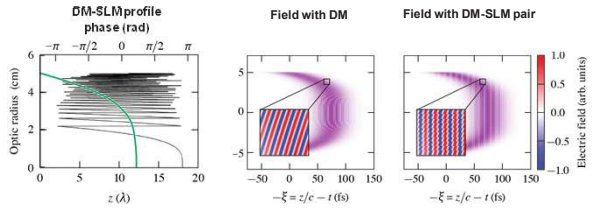
By tailoring the radial group delay, the trajectory of the ultrafast flying focus can be controlled.

Advanced Optics for Temporal Control: Echelon



The recently proposed[3] and demonstrated[8] radial echelon provides a reflective approach to structuring the radial group delay.

Advanced Optics for Temporal Control Deformable Mirror – Spatial Light Modulator Pair

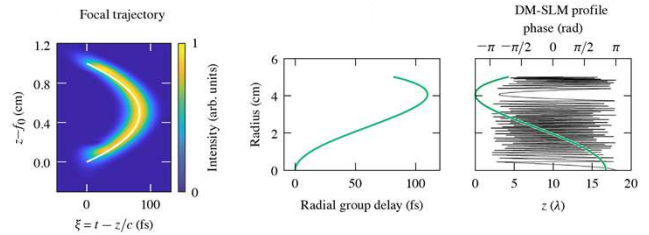


To improve upon the static echelon, adaptive optics can be used to tailor the radial group delay[6, 9].

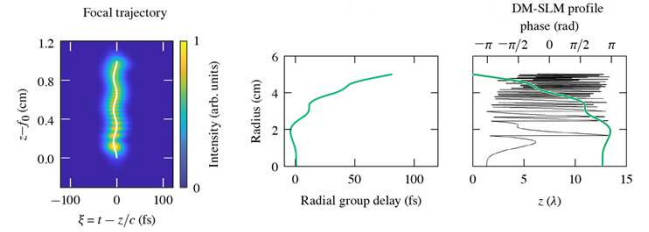
The DM imparts the desired radial group delay while introducing unwanted phase front distortion.

The SLM corrects the unwanted phase front distortion.

Exotic Focal Trajectories



An accelerating focus can be used to control the trapping and acceleration of electrons in a laser wakefield accelerator.



A pulse with an oscillating focal point could provide a novel method for quasi-phase-matching nonlinear optical processes.

Conclusions

- Flying focus pulses feature an intensity peak that can travel at any velocity, independent of the group velocity, over distances much longer than a Rayleigh range.
- We outline a generalized method for designing optical configurations that produce flying focus pulses with ultrashort duration and arbitrary, longitudinal focal trajectories at velocities close to the speed of light.
- We propose an axiparabola for extending the focal range and a deformable mirror – spatial light modulator pair to dynamically control the focal trajectory.

References

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Acknowledgements

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