Flying Focus and its Application to Plasma-Based Laser Amplifiers

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An advanced focusing scheme called a "flying focus" has been demonstrated, in which a diffractive lens combined with a chirped laser pulse enables a small-diameter laser focus to propagate nearly $100\times$ its Rayleigh length [1]. Furthermore, the speed at which the focus—and therefore the peak intensity—moves is decoupled from the group velocity of the laser; it was demonstrated to co- or counter-propagate along the laser axis at any velocity. Experiments validating the concept measured subluminal ($-0.09c$) to superluminal ($39c$) focal-spot velocities, generating a nearly constant peak intensity over 4.5 mm. We propose a new laser amplifier scheme utilizing stimulated Raman scattering in plasma in conjunction with such a flying focus [2]. Pump-intensity isosurfaces are made to propagate at $v \approx -c$ so as to be in sync with the injected counter-propagating seed pulse. By setting the pump intensity in the interaction region to be just above the ionization threshold of the background gas, an ionization wave is produced that travels a fixed distance ahead of the seed. Simulations show that this will make it possible to optimize the plasma temperature and mitigate many of the issues that are known to have impacted previous Raman amplification experiments, in particular, the growth of precursors. In addition to plasma-based laser amplifiers, the spatiotemporal control of laser intensity provided by the flying focus could mitigate dephasing in other plasma devices that produce, for example, tunable radiation and/or fast particles.

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References

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