The Green Option for NIF and LMJ Using STUD Pulses to Control LPI

Bedros AFEYAN [1] and Stefan Hüller

1) Polymath Research Inc., Pleasanton, CA

E-mail: bafeyan@gmail.com

2) CPhT, Ecole Polytechnique, Palaiseau, Fr

Four reasons for choosing the Green (second harmonic) option for the NIF and LMJ over the Blue (third harmonic), are the abundance of energy available to drive implosions (at least by a factor of 2), the increased bandwidth (at least by a factor of 4), longer and wider laser hot spots (by a factor of 1.5) and the potential factor of ~1.8 increase in the glass damage threshold. These four attributes combined allow ps time scale modulation of laser pulses, with high contrast (at least by a factor of 100 in intensity between successive "on" and "off" sections), lasting for tens of ns. Sub-ps synchronization between crossing beams also allows staggered and non-interacting or partially interacting beams that are otherwise overlapped in space. These capabilities together with spatial scrambling of laser hot spots via low density pre-plasma propagation constitute elements of the STUD pulse program which proposes to tame LPI by combining techniques from nonlinear optics, ultrafast optics and statistical optics. STUD pulses stands for Spike trains of Uneven Duration and Delay [1-4].

The gains made by deploying elements of the STUD pulse program far outweigh the inconvenience of a slightly longer wavelength drive. We will show theoretical and computational results on laser-plasma instability control using STUD pulses and compare them to RPP, SSD and ISI schemes and establish superiority. Single and multiple crossing beam scenarios will be considered. Memory effects accumulating locally at the single hot spot level via the plasma mode being constantly re-amplified, together with memory effects linking far away hot spots together in long chains that entail diffractive and non-geometric optics linked paths will also be shown to be essential in understanding how essentially stationary speckled beams (RPP, SSD) can be much more unstable that idealized plane wave models. Statistical tools will be introduced that demonstrate how STUD pulses democratize gain and heal memory effects and tame instabilities even when speckles are always present.

The best plan forward would be to demonstrate these capabilities on the Green KJ class laser Z-Beamlet, followed by single and then multiple quad implementations in the Green, on the NIF. How this could be done in the lab using arbitrary waveform generation techniques and detection of scattered light wave signatures with ps time resolution and with many ns long record lengths, and with spatial localization (using pump-probe techniques) is proposed.

References

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