Real-Time Assessment of Multi-Petawatt Focal-Spot *Via* Relativistic Electron Dynamics

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As we enter the era of multiple-beam experiments with tightly focused multi-petawatt lasers, there are several technical advances that are yet to be developed if such experiments are to be realized. Chief of among these is a real-time, full-power intensity-assessment tool that is implementable in real experiments. An on-shot technique to ensure and/or determine when two or more pulses overlap in time and space is essential. At the same time, for studies of the quantum vacuum, which is replete with virtual matter, an ability to prepare a "pure" physical vacuum – a condition devoid of all real matter – is necessary. We have addressed all three of these needs in two recent experimental campaigns (backed up by simulations), where we investigated relativistic ponderomotive ejection dynamics of free electrons in one and two strong fields. In [1,2] we show that the peak intensity is associated with the minimum ejection angle (θ_c) relative to the k-vector for electrons born in a paraxial field (i.e., loose focus). Exploiting the fact that $\tan\theta = \sqrt{2/(\gamma-1)}$, where $m_e c^2(\gamma-1)$ is the electron's kinetic energy and $\gamma_p - 1 \approx a_0^2/4$ [2], a_0 the normalized vector potential associated with the peak intensity and $I_p \propto a_0^2$. Our results suggest that the peak intensity can be assessed from a measurement of $\gamma_p - 1$, which is possible in both paraxial and non-paraxial fields with an angle-tuned magnetic spectrometer. Second, we demonstrated ponderomotive clearing of the focal volume with a pair of petawatt pulses. We showed that the efficiency of the clearing depends on the relative delay between the two pulses. In addition, the shot-to-shot fluctuation in this efficiency will provide a measure of shot-to-shot pulse overlap. Finally, our studies suggest a potential platform and approach for full-power assessment of each pulse used in an experiment. We will present details of our investigations and findings in this presentation.

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References

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