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Temperature effects in a plasma-wakefield accelerator

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Plasma-wakefield acceleration holds great promise for photon science and particle physics due to its extremely high accelerating gradients. However, plasma accelerators must also be capable of operating at very high repetition rates—orders of magnitude beyond the state of the art—to meet the brilliance and luminosity demands of users. Recent results from FLASHForward demonstrated that operation at the required MHz rates are possible in principle; the next step is to operate at (or close to) this rate in practice. However, doing so will result in the deposition of enormous amounts of beam power in the plasma, likely leading to far-from-equilibrium plasma conditions that must subsequently relax via multi-scale physics before the next acceleration event. Unfortunately relatively little is known about how this beam power evolves in the plasma and to the plasma stage over long (ns-μs) timescales and how the resulting background temperature increase will modify the subsequent plasma-electron and -ion response. Here we present novel numerical and experimental concepts to describe and map the key thermodynamics of state-of-the-art plasma accelerators, which is required to inform the design of future high-repetition-rate and high-average-power plasma accelerators, such as FLASHForward and HALHF.

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