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Efficient modeling of structure-based wakefield accelerators via separated representations

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Structure-based wakefield accelerators (SWFA) promise orders of magnitude improvements in accelerating gradient over conventional approaches and have been identified as a candidate technology for future applications ranging from compact free electron lasers to multi-TeV lepton colliders. However, achieving the desired beam energy and quality can require meter-scale structures with tight tolerances, introducing new constraints on structure and beam characteristics to minimize emittance growth and combat transverse instabilities. High fidelity and self-consistent simulations of high brightness beams over these lengths necessitate enormous computational resources, making parametric studies of novel structures or instability-mitigation schemes unfeasible with standard practices. We present a technique for decomposing high dimensional wakefield systems into a set of lower dimensional components, capable of accurately reconstructing the structure response in a fraction of the time. We discuss the approach and implementation of this technique using Green's Functions for common structure geometries. We demonstrate the potential for significant reduction in computation times and memory footprint using such representations. Finally, we discuss prospective extensions of this technique to higher dimensions, and explore the use of machine learning in generating these representations for novel structure geometries.

Working group

WG4 : Novel structure acceleration

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