Final Report for grant DE-FG02-06ER54886, "Simulation of Beam-Electron Cloud Interactions in Circular Accelerators Using Plasma Models"

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The primary goal of this collaborative proposal was to modify the code QuickPIC and apply it to study the long-time stability of beam propagation in low density electron clouds present in circular accelerators. The UCLA contribution to this collaborative proposal was in supporting the development of the pipelining scheme for the QuickPIC code, which extended the parallel scaling of this code by two orders of magnitude. The USC work was as described here the PhD research for Ms. Bing Feng, lead author in reference 2 below, who performed the research at USC under the guidance of the PI Tom Katsouleas and the collaboration of Dr. Decyk

The QuickPIC code [1] is a multi-scale Particle-in-Cell (PIC) code. The outer 3D code contains a beam which propagates through a long region of plasma and evolves slowly. The plasma response to this beam is modeled by slices of a 2D plasma code. This plasma response then is fed back to the beam code, and the process repeats. The pipelining is based on the observation that once the beam has passed a 2D slice, its response can be fed back to the beam immediately without waiting for the beam to pass all the other slices. Thus independent blocks of 2D slices from different time steps can be running simultaneously. The major difficulty was when particles at the edges needed to communicate with other blocks. Two versions of the pipelining scheme were developed, for the the full quasi-static code and the other for the basic quasi-static code used by this e-cloud proposal. Details of the pipelining scheme were published in [2]. The new version of QuickPIC was able to run with more than 1,000 processors, and was successfully applied in modeling e-clouds by our collaborators in this proposal [3-8].

Jean-Luc Vay at Lawrence Berkeley National Lab later implemented a similar basic quasistatic scheme including pipelining in the code WARP [9] and found good to very good quantitative agreement between the two codes in modeling e-clouds.

References

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