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James Clerk Maxwell Prize for Physics Talk: Simulations of Intense Laser and Beam Plasma Interactions, and Plasma Based Acceleration: Past, Present, and Future[1]

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Computer simulation is well established as a third pillar of science, along with theory and experiments. That was not the case over a half century ago when the division of plasma physics meeting began. Simulation rapidly became widely used in plasma physics due to the copious number of nonlinear wave-wave and wave-particle interactions occurring in plasmas, the need for both continuum and discrete descriptions, and its many applications. Simulations have been an indispensable tool for unraveling the nonlinear and relativistic physics involved in intense laser and beam plasma interactions since research on this topic began in earnest in the 1980s. Such interactions are the foundation for the field of plasma based acceleration (PBA). In PBA an intense and short laser pulse or particle beam propagates through long regions of plasma creating nonlinear plasma wave wakefields on which electrons or positrons surf to high energies. The seminal work in this field was based on one-dimensional particle-in-call simulations of small regions of plasma. With decades of improvement to hardware and algorithms it is now possible to simulate the entire space and time scales of current and future experiments in three-dimensions. The ability to model the full scales of experiments using first principles simulation has led to a close synergy between simulation and experiment. In this talk I will provide my own recollections and perspective on how PIC simulation capability has improved and how this capability has been a critical component in the rapid progress in PBA. The talk will include examples on how improvements continue to be made to the PIC method and how improved fidelity and performance are leading to new ideas, new concepts, and better understanding of the physics. I will also offer some perspectives on the exciting prospects for PBA in the near and distant future.

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