Adaptive and Multiscale Particle in Cell (PIC): Electro-Magnetic Simulations.

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In this lecture, we discuss our novel approaches to Particle in Cell (PIC) methods, based on adaptive and multiscale ideas.
While magnetic fusion deals with very different time and spatial scales (e.g. macro-scale MHD (magnetohydrodynamics) fluctuations and micro-turbulence at ion-scale), its underlying numerical methods as wel-known PIC methods have taken into account such scale-dependencies.
We are motivated to reduce computational time for a full-PIC cycle using information of the electro-magnetic field (e.g. near- and far-field). Mathematically, we have to solve scale-problems to fulfill the physical constraints of momentum-, energy and mass conservation of the scheme, if we apply adaptive mesh operations and we have taken into account numerical and physical errors.
We systematically derive error estimates of uniform and adaptive schemes based on the PIC-cycles. Based on higher order schemes for the shape and discretization methods, we see a perspective of designing novel methods to multiscale applications. The last results are discussed with numerical experiments to verify that the underlying conservation laws can be fulfilled with novel adaptive PIC methods.