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Multi-scale Modeling of Plasmas Using Adaptive Mesh Refinement Technique in Particle-in-Cell Simulations

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The strongly disparate temporal and spatial scales commonly occurring in many complex physical systems pose a significant computational challenge and necessitate a leap in simulation technology. Adaptive Mesh Refinement (AMR) is a well established method for selectively increasing the resolution of the numerical grid for both hydrodynamic and magnetohydrodynamic (MHD) simulation codes. It is extremely useful when dealing with problems that contain multiple scales, requiring high resolution for portions of the grid, but needing much less resolution elsewhere. By "zooming in" on only the affected regions, great computational savings can be achieved. However, the extension of this technique to particle-in-cell (PIC) simulations faces a number of challenges. In this presentation, we illustrate the issues and the remedies for AMR PIC simulations through several examples and show comparison with a uniform mesh PIC code. Finally, we discuss the first set of applications that can be attacked for the first time using this code.