3D Adaptive Mesh Refinement Simulations of Pellet Injection in Tokamaks

R. Samtaney[1], S. Jardin[1], P. Colella[2], D. Martin[2]

[1] *Princeton Plasma Physics Laboratory, Princeton, NJ 08543*
[2] *Lawrence Berkeley National Laboratory, Berkeley, CA 94720*

Abstract

Injecting small pellets of frozen hydrogen is a proven method of fueling tokamaks but a quantitative theory of mass redistribution during inside/outside injection is still lacking. We present results of Adaptive Mesh Refinement (AMR) simulations that quantify the MHD processes responsible for mass redistribution. AMR is essential to provide the resolution required to simulate realistic pellet sizes relative to device dimensions (typical ratios are $O(10^{-3})$). The mathematical model comprises of resistive MHD equations with source terms in the continuity equation along with a pellet ablation rate model. The numerical method developed is a high-accuracy explicit unsplit upwinding[1] treatment of the 8-wave formulation[2], coupled with a projection method to enforce the solenoidal property of the magnetic field. The Chombo[3] framework is used for AMR. Figure 1 shows the ablated mass distributed along magnetic field lines at early time. Preliminary studies indicate that AMR provides a speed-up exceeding two orders of magnitude over corresponding uniform mesh simulations essential to accurately resolve the physical processes involved in pellet injection.

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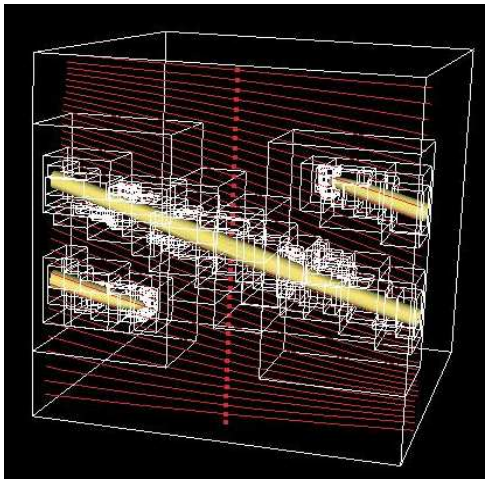

Figure 1: Density isosurface at early time during pellet injection in a periodic cylinder shows mass reditribution along field lines (in red). The boxes of the various meshes in the AMR simulation are shown in white lines.