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Resistive MHD Simulations with Roxane

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Abstract

We discuss the efficacy of the adaptive mesh refinement (AMR) code ROXANE in performing resistive Magnetohydrodynamic (MHD) simulations. Two-dimensional simulations with ROXANE for a generic Z-pinch setup for imploding a cylindrical liner shows that random hotspots known to occur in other codes in the insulator region are absent here. Furthermore, artificial instabilities present in other codes due to mesh imprinting are not present in ROXANE. The fundamental reasons for the better performance of ROXANE in resistive MHD simulations is the interface treatment in a cell containing two conductors (materials), avoiding the artificial mixing of disparate resistivities.

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I. INTRODUCTION

We have performed proof-of-principle resistive MHD simulations of a generic Z-pinch setup in cylindrical geometry using ROXANE. A new method was recently implemented to prevent resistivities of two materials present in a given cell from mixing erroneously.

We find as expected that the cylindrical liner with a uniform thickness starts moving relatively slowly, then picks up speed as convergence increases. But unlike other numerical methods, the metal/insulator and metal/gas interfaces show no evidence of RMI-related undulations seeded numerically via mesh-imprinting.

This is exhibited in the following figures. They display density contours on the right half of each figure in g/cc, while the left half of each figure shows electron temperature contours in keV.

We used a gold liner having a uniform thickness of 0.1 mm (100 microns). The energy delivered to the liner was estimated to be about 10 kJ. Glide planes are made of gold. No effort was made to optimize the design, e.g., by tuning the liner thickness such that minimum volume is attained when current is at its maximum.

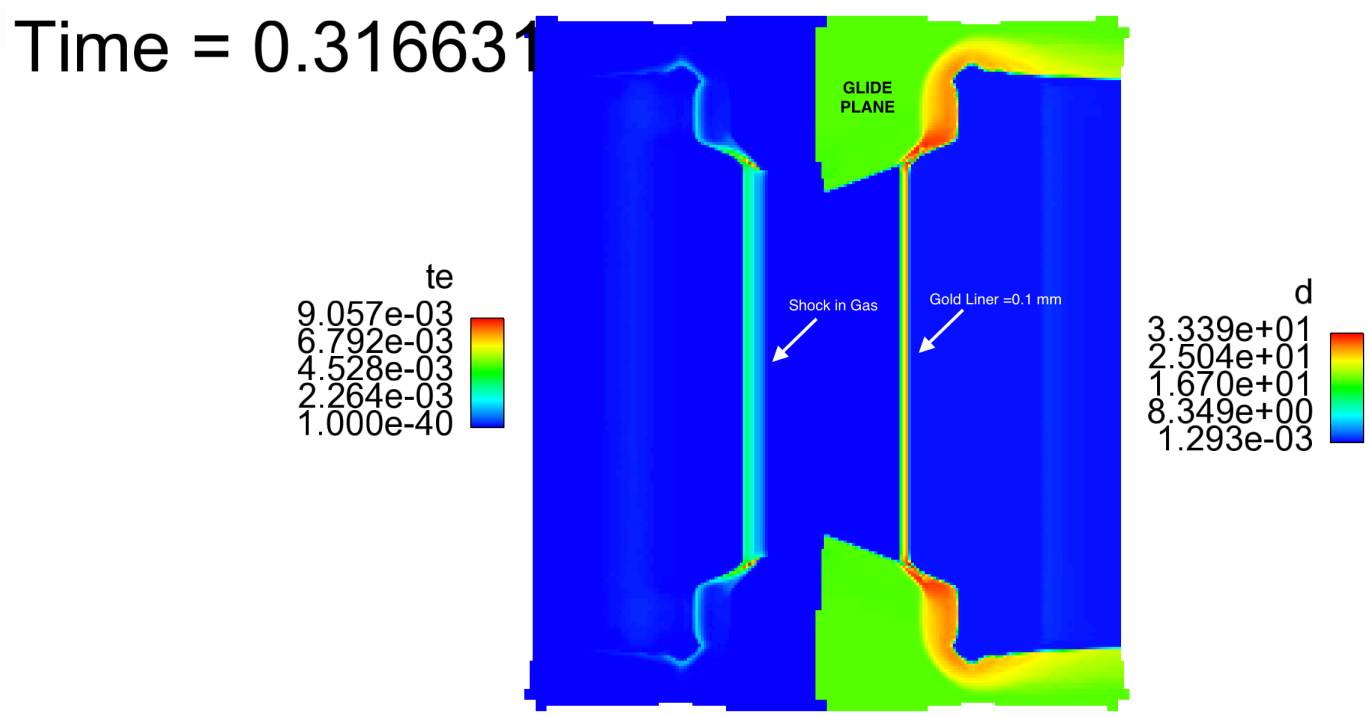

FIG. 1. Density contours in the right half half near the beginning of the implosion. The left half of the figure shows contours of the electron temperature.

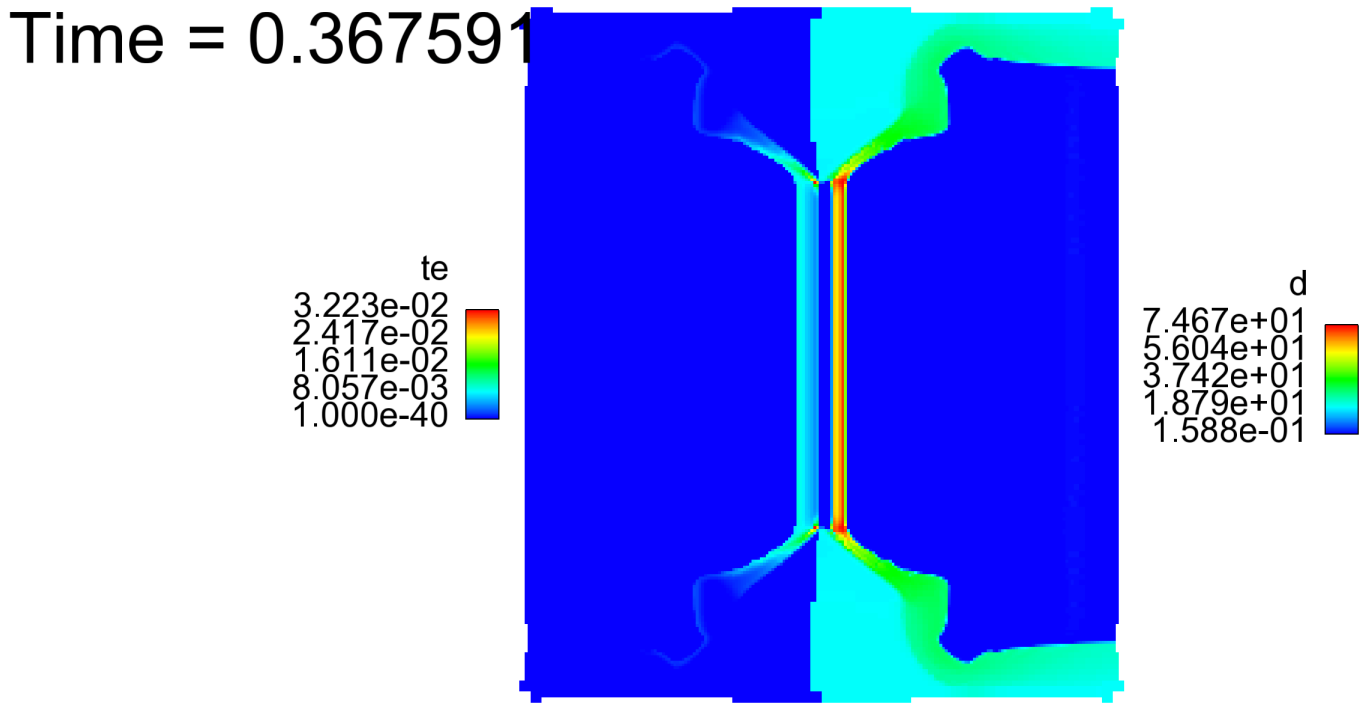

FIG. 2. Density contours the right half at $0.368\mu s$. The left half of the figure shows contours of the electron temperature. The gas temperature is about 80 eV.

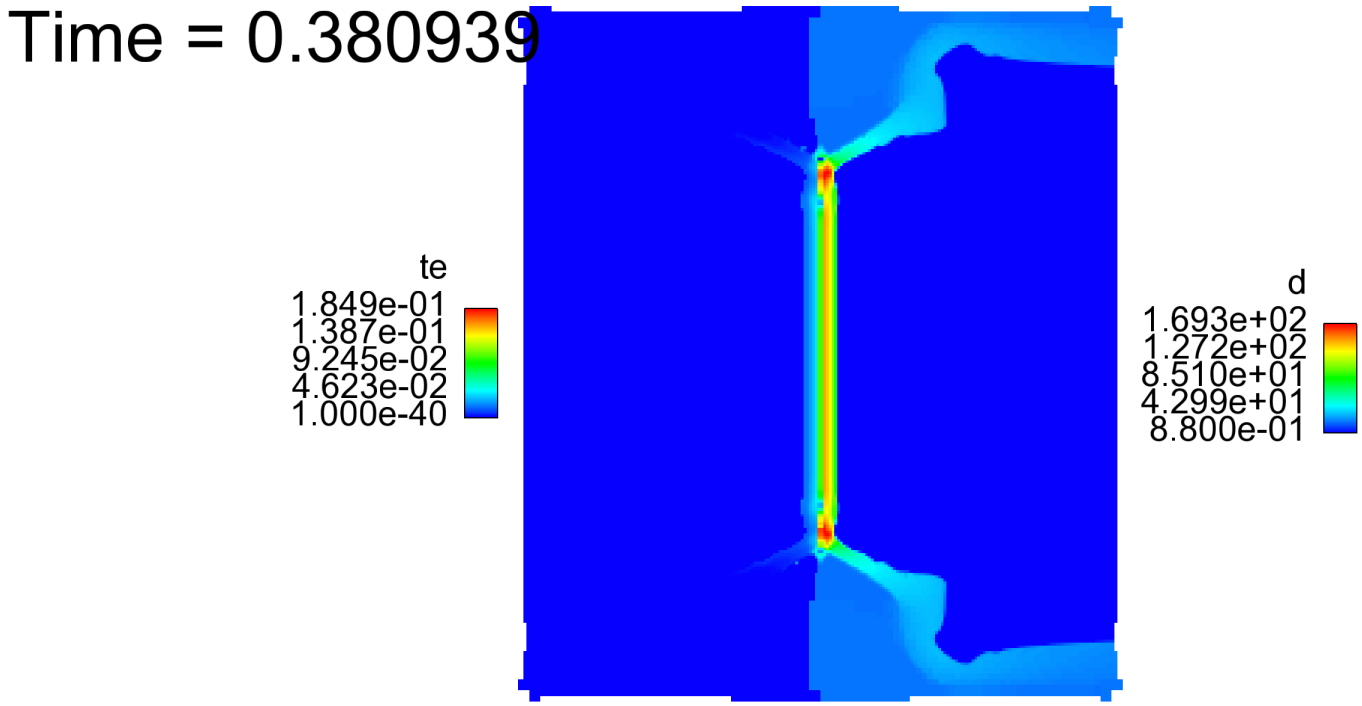

FIG. 3. Density contours in the right half at $0.638\mu s$. The left half of the figure shows contours of the electron temperature.