Lagrangian Schemes for the Simulation of Inertial Confinement Fusion in the Direct Drive Context

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The demonstration of thermonuclear ignition and gain in laboratory by means of controlled fusion is a technical and scientific challenge. The aim of controlled fusion is to develop approaches which would be applicable to energy production. There are two main ways to obtain controlled fusion. The first one, which is named Magnetic Confinement Fusion (MCF), uses magnetics fields to confine low density high temperature plasma. The International Thermonuclear Experimental Reactor (ITER) has been designed in order to study the MCF approach. The second one, is the Inertial Confinement Fusion (ICF), which relies on the inertia of the reacting fuel mass to provide confinement. By means of a high power laser a small amount of fusion fuel is compressed to high density and temperature in order to ignite a thermonuclear burn. The National Ignition Facility (NIF) in the USA and the Laser Megajoule in France have been designed to reach ignition. There are two main approaches to ICF: direct drive and indirect drive. In the indirect drive approach, the driver beams are first used to produce x-rays, which are then used to implode the fusion fuel. In the direct drive context, the driver beams are aimed directly at the capsule containing the fusion fuel. This configuration is the most efficient way of coupling driver energy, but it is very sensitive to spatial structures in the driving beams and to hydrodynamics instabilities.

In this talk, we shall focus on the numerical flow models used for the design and the control of ICF experiments in the direct drive context. The plasma flow is described by a fluid model written in Lagrangian form. We shall detail this model and the specific numerical methods developped to solve the corresponding equations. First, we will present a new Lagrangian scheme for solving two-dimensional compressible flows. Then, we will describe a new cell-centered high order diffusion scheme devoted to the simulation of energy transport. We will also give a description of an Arbitrary Lagrangian Eulerian (ALE) strategy developped for ICF flows. Finally, we will show some examples of two-dimensional ICF computations.

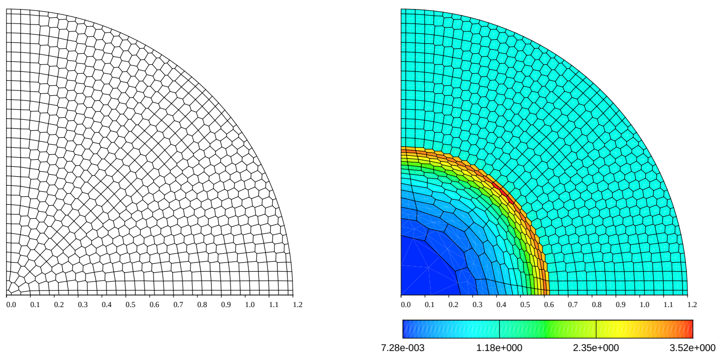

Figure 1: Sedov blast wave on a polygonal mesh : initial mesh (left), final mesh and density contour at $t = 0.1$ (right).