A Cell-Centered Arbitrary Lagrangian-Eulerian Method

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- **Introduction**

The purpose of this presentation is to describe an original and a complete ALE strategy devoted to the computation of Inertial Confinement Fusion (ICF) flows. The main elements in an ALE simulation are an explicit Lagrangian step, a rezoning step in which nodes of the Lagrangian grid are moved to improve geometric quality of the grid, and a remapping step in which the Lagrangian solution is reconstructed on the rezoned grid. We will describe each of these steps in the sequel.

- **Lagrangian step**

The Lagrangian step is based on a new second order cell-centered Lagrangian scheme. The primary variables in this scheme are specific volume, momentum and total energy. The vertex velocities and the numerical fluxes through the cell interfaces are not computed independently contrary to standard approaches but are evaluated in a consistent manner due to an original solver located at the nodes. This nodal can be viewed as a a two-dimensional extension of the Godunov acoustic solver. The second order extension is derived using a MUSCL type approach.

- **Rezoning step**

The rezoning step is combined into a 3-step procedure. The first step of the procedure performs the minimization of a quadratic objective function in order to smooth the grid. We have developped specific objective functions in order to adapt the grid motion to the fluid flow. We improve the quality of the interface smoothing by repositioning its nodes such that they are constrained to remain on a Bezier curve. Moreover, there are no numerical fluxes through the interfaces. This treatment preserve a quasi Lagrangian interface tracking. The second step of the procedure is a local control of the admissible smoothing displacement of the nodes. This procedure allows the repositioning of the nodes such that the velocity displacement of the smoothed node is lower than the virtual velocity displacement of the Lagrangian node. The third step of the procedure performs a global control and an improvement of the geometric quality of the grid, when previous procedures cause the grid to become tangled or non-convex. The need of such a procedure also exits when the Lagrangian step creates non valid elements in a grid.

- **Remapping step**

The remapping step is an interpolation procedure of mass, momentum and total energy, from the Lagrangian grid, to the rezoned one. The method we use is an unstructured and a cell-centered extension of the swept displacement face flux computation. This approach does not need the computation of the intersections of the old grid and the corresponding rezoned one, which makes this approach much more efficient. The fluxes are reconstructed using a second order linear reconstruction.

Many numerical tests are presented. They are representative test cases for ALE simulations and demonstrate the robustness and the accuracy of this method.