Sliding and multifluid velocities in Staggerred Mesh MMALE codes

Gabi Luttwak[1]
[1]*Rafael , P.O.Box 2250,Haifa 31021,Israel*

In Multi-Material Arbitrary Lagrangian Eulerian (MMALE) codes the material boundaries may cut the mesh lines. The cells cut by the interface include several fluids and the interface position is resolved by a multi-dimensional interface reconstruction consistent with the volume of the fluids (VOF) in the neighbouring cells. The position of the interface serves to define the material fluxes preventing unphysical mixing of the materials. At a material interface the pressure and the normal component of velocity are continuous, but there may be a jump in the tangential component of the velocity. Lagrangian slide-line and sliding-impacting surface calculations does take this into account, however most Eulerian and MMALE codes traditionally assume a common velocity in multi-material cells. Such a procedure prevents sliding, or at least adds an effective numerical and mesh size dependant, thus un-physical friction. In a hyperbolic problem all the solution field depends on the motion at the boundaries thus in some cases this assumption can lead to large errors. This is not necessary. In one of the first published MMALE codes [1], we allowed distinct fluid nodal velocities, while enforcing a common normal to interface component. Walker and Anderson [2] added cell-centered multi-material velocities to the code CTH. We have recently investigated the advantages of using a Staggered Mesh Godunov scheme [3] for ALE and MMALE calculations. This scheme was shown to capture sharp shocks while having a "natural" capability of damping the hourglass instability. In the current work, we add multi-fluid nodal velocities to the code. This is done like in [1] which some changes to make the procedure quicker and to preserve full consistency between the vertex masses of the species and the masses of the amount of those materials in the neighbouring cells.

[1]G. Luttwak, R.L.Rabie, "Multimaterial Arbitrary Lagrangian Eulerian code MMALE and its application to some problems of penetration and impact", LA-UR-85-2311,(1985)
[2]J.D.Walker,C.E.Anderson,"Multimaterial velocities for mixed cells",p1773-1776, High Pressure Science and Technology-1993,ed. Schmidt et al.,AIP, (1994)

[3] Gabi Luttwak, Joseph Falcovitz, "Staggered Mesh Godunov (SMG) Schemes for ALE Hydrodynamics", presented at the Numerical methods for multi-material fluid flows held at Oxford, Sept.2005