A high order cell centred Lagrangian Godunov scheme for cylindrical geometry

Andrew J. Barlow

Computational Physics Group, AWE Aldermaston, UK

Contact e-mail: andy.barlow@awe.co.uk

ABSTRACT

Most Lagrangian hydrocodes have been written within the framework of a staggered grid. These have proved extremely useful, but they share some defects such as mesh imprinting, failure to maintain symmetry, and some fail to conserve total energy. It is also possible to take a cell-centred approach, as is common with Eulerian hydrocodes, which makes full conservation straightforward. The fluxes across interfaces can be derived from Riemann solvers, which have proved very robust in the Eulerian context, and avoid the need for such measures as artificial viscosity and subzonal pressures. The outstanding issue seems to be the development of a good method for moving the mesh along with the flow. However, significant progress has recently been made in solving this problem [1]. Most Lagrangian Godunov schemes either define the nodal velocities as averages of adjacent cell centred velocities or edge velocities (from the Riemann solver), or introduce a special nodal Riemann solver [1]. We propose here to derive the mesh motion by surrounding each cell vertex with a control volume to which the conservation laws are applied. We describe this as a dual grid. A first order version of this scheme was described in [2]. This method has now been extended into a second order scheme in space and time and it has been shown that this second order scheme provides comparable shock capturing to staggered grid methods while retaining the benefits of reduced mesh imprinting, robustness and improved symmetry preservation observed for the first order scheme. This has been demonstrated by performing test problem comparisons against a staggered compatible finite element hydro scheme [3]. The method has also been extended to provide a capability to perform simulations in cylindrical geometry. The results obtained from test problems in cylindrical geometry suggest even greater benefits particularly in terms of symmetry preservation with the new cell centred approach over staggered grid methods. This talk will describe the improvements that have been made to the cell centred scheme, including the extension to second order accuracy, cylindrical geometry and initial progress with the inclusion of an elasto-plastic flow capability. Results of test problems will also be presented to demonstrate the performance of the cell centred scheme by comparison with a staggered compatible finite element hydro scheme [3].

References

1. P.-H. Maire, A high-order cell-centered Lagrangian scheme for two-dimensional compressible fluid flows on unstructured mesh, Journal of Computational Physics, 228 (7), 2391-2425 (2009).

2. A. J. Barlow, P. L. Roe, A cell centred Lagrangian Godunov scheme for shock hydrodynamics, Comput. Fluids, 46, 133-136, (2011).

3. A. J. Barlow, ‘A compatible finite element multi-material ALE hydrodynamics algorithm.’, Int. J. Numer. Meth. Fluids 2008; 56:953-964.