Utilisation of Harten Multiresolution in scientific computing: two examples.

Guillaume Chiavassa

Ecole Centrale Marseille

Laboratoire de Mécanique Modélisation et Procédés Propres, (M2P2,) France

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Abstract

The first example will be devoted to simulations of high Mach number flows in the presence of obstacles. When considering the compressible Navier-Stokes equations to model large Mach flows, an adequate numerical treatment of shock waves can be achieved through the use of high-resolution shock capturing techniques in the discretization of the convective fluxes. On the other hand, the presence of obstacles in the flow is a complex issue that has been handled using a variety of techniques, from coordinate transformations and body fitted structured and unstructured grids to fictitious domain approaches.

A elegant and now popular way of introducing obstacles in cartesian grids, is the penalization method introduced by Arquis and Caltagirone [1] for incompressible flows. This method introduces supplementary terms in the initial system of equations in order to enforce the boundary conditions. The new system is then solved in an obstacle free domain.

Nevertheless this method suffers from two main drawbacks: the size of the mesh must be very fine around obstacles to avoid the introduction of large errors in the numerical solution, and computations are also made inside of the obstacles which can increase significantly the cpu time in comparison to other approaches like body fitted ones for example.

We have developed a penalization method for compressible Navier-Stokes flows [2] and I will demonstrate in this talk that the introduction of Harten's multilevel technique allows to perform fine mesh simulations avoiding most of the computations inside the obstacles. Accurate simulations around complex geometrical configurations can be achieved at low cpu time cost.

The second example I will present concerns the propagation of acoustic waves in porous media. This problem is particularly tricky from computational point of vue [3], due to the coexistence of a propagating fast wave and a diffusive slow wave. The ratio of wavelength sizes can be larger than 60 for real media and accurate numerical representation of both waves requires necessarily local mesh-time reffinements in 2D. Nevertheless, even with this method, realistic computations are out of reach for personal computers due to huge cpu time.

I will explain how the introduction of Harten technique inside the AMR algorithm reduces drastically the cpu time while keeping the same accuracy of the results.

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[1] E. Arquis, J.P.Caltagirone, *Sur les conditions hydrodynamiques au voisinage d'une interface milieu fluide-milieu poreux: application à la convection naturelle*, C.R. Acad. Sci. Paris II, 299 (1984), pp 1-4.

[2] O. Boiron, G. Chiavassa and R. Donat: *A High-Resolution Penalization method for large Mach number flows in the presence of obstacles*, Computers and Fluids (doi:101016/j.compfluid.2008.07.003), 2008.

[3] G. Chiavassa, B. Lombard and J. Piraux: *Numerical modeling of 1-D transient poroelastic waves in the low-frequency range*, to appear J. Comput. Appl. Math., 2009. (hal.archives-ouvertes.fr/hal-00193103/fr/)