A self-adaptive flux-vector-splitting scheme capturing the multi-scale waves of compressible low-velocity flows

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The purpose of the presentation is motivated by a rather disturbing observation: when the considered fluid is endowed with a stiff equation of state, there can exist configurations in which strong pressure jumps occur *even if* the Mach number flow M is uniformly low. *Water Hammer* scenarios, triggered in liquid water, perfectly illustrate this phenomenon.

Along the presentation, a time-explicit adaptive Flux-Vector-Splitting (FVS) scheme will be described. It stems from an operator-splitting analysis [1], performed on the Euler compressible system, separating convection from the acoustic wave production. The term "adaptive" refers to the presence, inside the numerical flux, of a locally-varying parameter whose aim is to detect the transition between three different regimes:

(1) Fully compressible flows
(M of order 1 or superior to 1)

(2) Low-velocity compressible flows with strong pressure jumps occurrences
(M uniformly lower than 1, water hammers)

(3) Low-velocity compressible flows with no strong pressure jumps occurrences
(M uniformly lower than 1, quasi-incompressible regime)

For both regimes **(1)** and **(2)**, the present approach naturally turns into a classical approximate Riemann solver for the full Euler equations, while in the context of regime **(3)**, a low-Mach correction is applied on the acoustic part of its numerical flux. Therefore, this strategy offers a satisfying trade-off between the fact to optimally capture strong shock or rarefaction waves and remain close enough to the incompressible-part of the solution when the pressure transients have faded away.

The present method has been applied to various test cases covering the three above mentioned regimes. Accuracy and efficiency comparisons with respect to classical Riemann solvers (HLLC, [2]) and low-Mach corrected solvers (low-Mach-AUSM$^+$-up, [3]) have been carried out.

Références

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