A novel numerical flux for the 3D Euler equations with general equation of state

Eleuterio F. Toro[a], Cristóbal E. Castro[b], Bok Jik Lee[c]

[a] *Laboratory of Applied Mathematics, DICAM. University of Trento, Trento, Italy*
[b] *Escuela Universitaria de Ingeniería Mecánica, Universidad de Tarapacá, Arica, Chile*
[c] *Clean Combustion Research Center, King Abdullah University of Science and Technology, Thuwal, Saudi Arabia.*

Abstract

Here we extend the flux vector splitting approach recently proposed in (*E F Toro and M E Vázquez-Cendón. Flux splitting schemes for the Euler equations. Computers and Fluids. Vol. 70, Pages 1-12, 2012*). The scheme was originally presented for the 1D Euler equations for ideal gases and its extension presented in this paper is threefold: (i) we solve the three-dimensional Euler equations on general meshes; (ii) we use a general equation of state; and (iii) we achieve high order of accuracy in both space and time through application of the semi-discrete ADER methodology on general meshes. The resulting methods are systematically assessed for accuracy, robustness and efficiency on a carefully selected suite of test problems. Formal high accuracy is assessed through convergence rates studies for schemes of up to 4th order of accuracy in both space and time on unstructured meshes.

Keywords: Hyperbolic systems, upwinding, flux vector splitting, Euler equations, general equation of state, ADER method.

1. Introduction

Advanced computational methods for compressible flow rely on a first-order, monotone (for the scalar case) scheme as the building block. Though there seems to be an endless proliferation of publications aiming at the *ultimate numerical flux*, identifying a single scheme that is optimal for all cases of practical interest seems to be an impossible task. And hence the labouring goes on. Proposed methods fall essentially into two classes: upwind methods and centred or symmetric methods. In spite of their increased complexity, upwind methods tend to be preferred when having to resolve fine features, particularly those associated with intermediate characteristic fields. Then two possible choices are the

Email addresses: eleuterio.toro@unitn.it (Eleuterio F. Toro), ccastro@uta.cl (Cristóbal E. Castro), BokJik.Lee@KAUST.EDU.SA (Bok Jik Lee)