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On the modelling of compressible inviscid flow problems using AUSM schemes

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Abstract

During last decades, upwind schemes have become a popular method in the field of computational fluid dynamics. Although they are only first order accurate, AUSM (Advection Upstream Splitting Method) schemes proved to be well suited for modelling of compressible flows due to their robustness and ability of capturing shock discontinuities. In this paper, we review the composition of the AUSM flux-vector splitting scheme and its improved version noted AUSM+, proposed by Liou, for the solution of the Euler equations. Mach number splitting functions operating with values from adjacent cells are used to determine numerical convective fluxes and pressure splitting is used for the evaluation of numerical pressure fluxes. Both versions of the AUSM scheme are applied for solving some test problems such as one-dimensional shock tube problem and three-dimensional GAMM channel. Features of the schemes are discussed in comparison with some explicit central schemes of the first order accuracy (Lax-Friedrichs) and of the second order accuracy (MacCormack).

Keywords: compressible flow, Euler equations, AUSM scheme, flux-vector splitting, shock tube problem, 3D GAMM channel

1. Introduction

The growth of interest in computational fluid dynamics in 1980s brought the development of sufficiently robust, accurate and efficient numerical methods. Especially, upwind schemes proved to be efficient for the solution of compressible inviscid flow problems described by the non-linear system of the Euler equations. Recently, upwind schemes have become well-used for their accuracy with regard to other first order accurate schemes (e.g. central explicit Lax-Friedrichs scheme) and for their capability of capturing shock and contact discontinuities in a wide variety of problems.

In 1990, the AUSM scheme was presented as a simple, first order accurate and robust method in comparison with existing numerical schemes and became early one of the most used computational fluid dynamics techniques. Several attempts have been made in the following years to improve the original AUSM scheme proposed by Liou and Steffen, [5]. Various types of flux splittings, [4], have been tested to increase accuracy and to reduce numerical diffusion. Various versions of the AUSM-family schemes have been written into numerical codes.

In this paper, we review the finite volume formulation of the first order accurate AUSM scheme proposed by Liou and Steffen, [5]. Secondly, we mention an improved AUSM+ scheme, [3], having following features: exact resolution of stationary shock discontinuities, positivity

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