Making of AUSM-Family Schemes: Analysis and Applications

Meng-Sing Liou
NASA Glenn Research Center, MS 5-11, Cleveland, Ohio 44135, USA, meng-sing.liou-1@nasa.gov

Abstract

Considerable progress in the development of numerical schemes for CFD has been made over the last three decades. It is widely accepted that the approximation of inviscid flux plays a crucial role in determining accuracy and robustness of a numerical solution, especially in the resolution of shock waves and contact discontinuities. The 1980s is arguably a decisive era in CFD, with the introduction of upwind schemes, specifically those belonging to the class of so-called approximate Riemann solvers. Today, upwind schemes have become a predominant approach and most codes include at least one form of upwind schemes.

In this paper, we will first describe the motivation for which the AUSM scheme started, in view of approximate Riemann solvers. We will elucidate the ideas for constructing the numerical inviscid flux and discuss its numerical properties. While the original scheme (Liou and Steffen, 1991) has proven to have distinctive features over other schemes, weaknesses have also been discovered, for example, pressure oscillations adjacent to the wall across the boundary layer. Hence, several remedies proposed over the last few years by various researchers to overcome this shortcoming will be discussed.

As CFD is becoming accepted routinely for solving complex problems intractable by other means, the need for considering other types of flows increases and extension of the basic scheme become necessary. The issues of accuracy, simplicity, and robustness remain to be of primary concern. In this presentation, we will focus on two extensions, namely the low Mach number regime, and multiphase flows, and we will show the recent development of the AUSM schemes in this regard.

To demonstrate the effectiveness and reliability of the schemes, their applications to both benchmark and realistic engineering problems will be given.