Comparative Study of AUSM-Family Schemes in Compressible Multiphase Flow Simulations

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Abstract: AUSM-Family schemes are extended for compressible multiphase flow computations based on stratified flow model concept. By varying schemes and parameters, both features and limitations of the existing methods are addressed through several benchmark tests. Then, some keys to enhance both stability and accuracy will be explored for further development of numerical methods for multiphase flows.

Keywords: Multiphase Flow, Computational Fluid Dynamics, Numerical Algorithms, AUSM-Family, Stratified Flow Model.

1 Introduction

Multiphase flow computations have been attracting many researchers and practitioners over wide-ranging fields of study for several decades [8]. Some recent studies have been dedicated to extend incompressible flow methods to compressible flows, because compressible methods obviously have more applicability [6]. As a result, while we have many approaches for compressible multiphase flows with their own pros and cons, it is difficult for users or beginner researchers to choose appropriate methods to meet their demands (see Figure 1). Among them, a novel approach was proposed in [1], which is based on the stratified flow model concept [5] and can easily be extended from single-phase compressible codes using AUSM$^+$-up [2] flux function. AUSM$^+$-up belongs to AUSM-family schemes and they typically behave very well in single-phase gas flows from low speed to hypersonic, yet they have not fully been surveyed in multiphase flows. In addition, in [1], some ambiguity remained in choice of (numerical) speed of sound at a phase interface and in other built-in parameters. In the present study, the work in [1] is extended to AUSM$^+$-up with different parameters and other AUSM-family schemes [3][4] first. Then, through several test cases with varying schemes and parameters, features and limitations of the present methods will be addressed along with comparisons with others. Some keys will also be explored to enhance both stability and accuracy, and to extend applicability. Hopefully this piece of information will make a clue for further development of numerical methods for multiphase flows.

2 Numerical Method and Test Cases

Within the framework of a finite-volume, shock-capturing method, we follow the concept of stratified flow model proposed in [5], and applied methods in [1] with AUSM-family flux functions of AUSM$^+$-up [2], SLAU [3], SLAU2 and others [4]. These schemes have satisfactory performance in single-phase gas flows from low speed to hypersonic, but have not been fully surveyed in multiphase flows yet. The numerical code solves Euler equations for two-fluid, extended from single-fluid version previously used in [7]. Some benchmark problems will be conducted, such as moving (phase) discontinuity (see Figure 2; phase interface is reasonably captured with constant pressure by spatially 2nd-order scheme), Faucet problem, air-water shock tube, shock-bubble interaction [5].

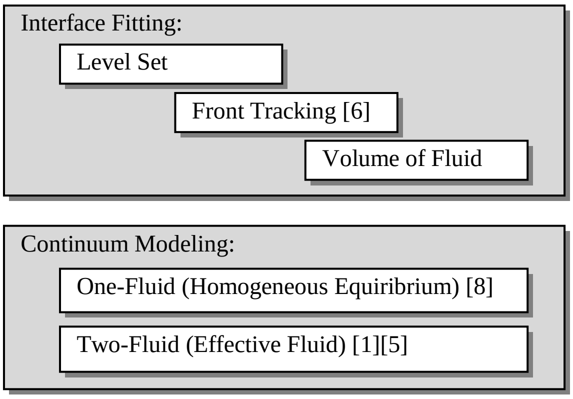

Figure 1: Various Methods for Multiphase Flow Computations [8].

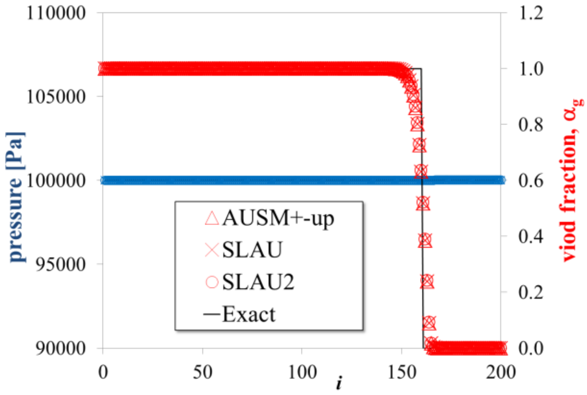

Figure 2: Moving Phase Discontinuity Problem.

3 Final Paper

In the final paper we will present results for other test cases and make comparisons. Features and limitations of each method will also be addressed.

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