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Investigating Unsteady Flow Physics Using an Improved Finite Volume Scheme

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Computational Fluid Dynamics (CFD) continues to play a critical role in the solution of complex fluid dynamics flows. This computational tool allows us to investigate complex flow patterns that would otherwise be impossible to investigate, and has greatly aided in the development of our knowledgebase. At the heart of successful CFD tools are the creative numerical schemes that are developed and used in an attempt to capture ‘real world’ flow physics. One such creative numerical scheme in the Integral-Differential Scheme (IDS)[1]. This scheme is developed based on a unique combination of the differential and integral forms of the complete Navier-Stokes Equations coupled with a consistent averaging methodology. The IDS numerical scheme can be used on a number of complex fluid flow problems ranging from complex 2-D flows to quasi-1D flows through a nozzle. Initial testing of the scheme has demonstrated its robustness associated with complex flows under different conditions. Additionally, a thorough analysis of the temporal and spatial error associated with the use of the IDS scheme was conducted using a numerical experimental methodology. The results indicate that the IDS scheme is first order accurate but approaches second order as the grid is refined. In this paper however, we study the underlying physics for unsteady flow using the IDS with examples stemming from the classical 1D Sod Shock Tube Problem[2], the Quasi-1D shock tube Problem as illustrated in Fig. 1 and the 2D Taylor Green Vortex Problem in Fig. 2. The results reveal that the IDS can capture the unsteady behaviour, further indicating that at every timestep the solution from the IDS is an exact solution.

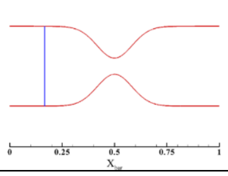

Fig.1 Quasi 1D Shock Tube

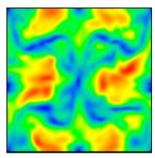

Fig.2 2D Taylor-Green Vortex Problem[3]

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