Numerical modeling of magnetic field effects in gas flow using an extended AUFSR scheme

Ghislain Tchuen[1*], Ferdinand Fogang[2] and Yves Burtschell[3]

[1]Institut Universitaire de Technologie F-V, LISIE, Université de Dschang, BP. 134 Bandjoun - Cameroun.
[2] Université de Yaoundé I, Faculté de Sciences, BP.8210, Yaoundé, Cameroun
[3]Ecole Polytechnique Universitaire de Marseille, Université de Provence, DME, 5 rue Enrico Fermi Technopole de Chateau Gombert, 13453 Marseille Cedex 13, France.

ABSTRACT The magnetic field can be coupled with a gas flow to accelerate or decelerate the flow, thus delaying the separation of the boundary layer, or control the friction and heat transfer. The mastery of this coupling facilitates the flow control for improved performance aerodynamic. This requires the ability to solve the complex equation of magnetohydrodynamics (MHD) that is available today through the power of computers and robust numerical methods existing. The AUFSR scheme has been presented for solving the Euler equations [1]. The performances of this scheme were evaluated through several test cases and proved his capabilities to eliminate unphysical solutions that may arise from the use of many approximate Riemann solver. An extension to ideal magneto-hydrodynamics (MHD) must be conducted. The scheme takes into account all MHD waves such that slow, fast, Alfven and entropy waves into the flux decomposition.

The numerical simulation shows great impact of the transverse magnetic field on the structure of the flow field. The results in figure 1 shows the influence of the inclusion of a constant magnetic field $B_x = 0,75T$ in the test of Sod. One notes a perturbation of the flow with a significant dimunition of internal energy due to the presence of the magnetic field. Figure 2 shows the MHD spherical blast problem which leads to the formation and propagation of strong discontinuities, relevant to mechanical applications where the magnetic field energy has strong dynamical effects. The explosion is driven by an over-pressurized circular region at the center of the domain with a radius is $R = 0.1$. The initial conditions results in very low-$\beta(\beta = 0.000251)$ ambient plasma states are described by $\rho = 1.0, u = 0.0, v = 0.0, w = 0.0, B_x = 100.0/\sqrt{4 * \pi}, B_y = 0.0, B_z = 0.0$. The explosion emits almost spherical fast magneto-sonic shocks that propagate with the fastest speed in both positive and negative directions.

Several two-dimensional hypersonic flowfield problems are computed to show capability of the method to investigate ideal MHD compressible flow. The work will conducted fundamental and numerical studies of MHD-control flow.

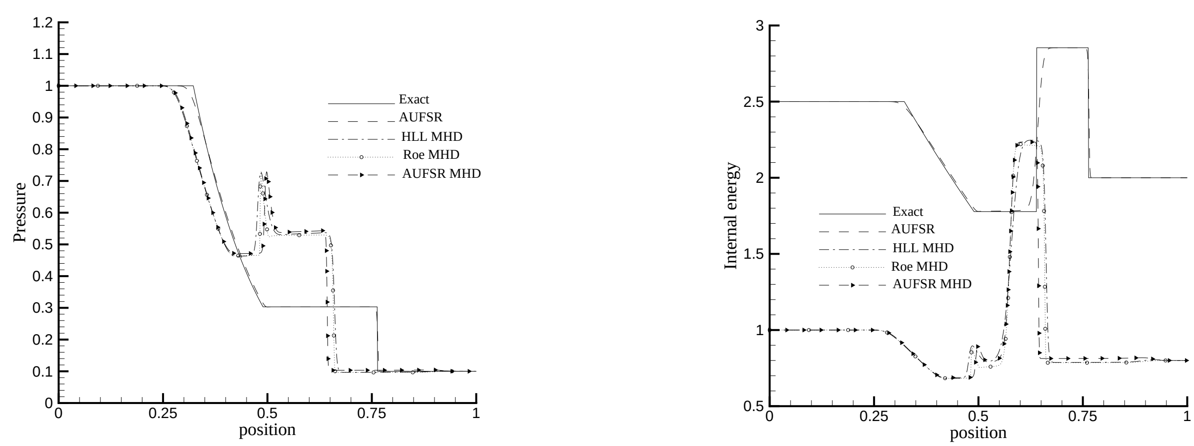

Figure 1: $B_x = 0,75$ Sod's test, t=0,2U

[1*] Corresponding author : Ghislain Tchuen
(e-mail: tchuengse@yahoo.com)

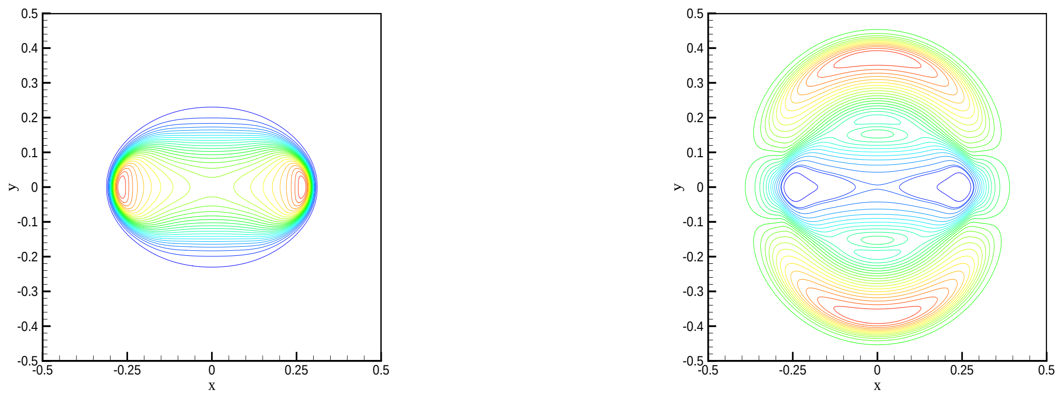

Figure 2: Blast wave, (a) Gas pressure lines and (b) Magnetic pressure lines at t=0.01

References

[1] Tchuen G., Fogang F., Burtschell Y., and Woafo P.: Hybrid upwind splitting scheme by combining the approaches of Roe and AUFS for compressible flow problems. International Journal of Enginneering Systems Modelling and Simulation, 2011, Vol. 3, Nos 1/2, pp. 16-25.