The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5-9 June 2022, Oslo, Norway

SYMMETRY-PRESERVING DISCRETISATION METHODS FOR MAGNETOHYDRODYNAMICS

J.A. Hopman[1], F.X. Trias[1] and J. Rigola[1]

[1] Heat and Mass Transfer Technological Center, Technical University of Catalonia, ESEIAAT, c/Colom 11, 08222 Terrassa, Spain, jannes.hopman@upc.edu

Keywords: *Symmetry-preserving discretisation, Magnetohydrodynamics, OpenFOAM*

A symmetry-preserving fully conservative solver for magnetohydrodynamic (MHD) flows is presented in this work. MHD flows at high Hartmann numbers (Ha) and low magnetic Reynolds numbers are of great interest in the development of a fusion reactor blanket. At high Ha, the large flow opposing Lorentz force is balanced by an equally large pressure drop. A non-conservative discretisation inevitably leads to numerical errors causing inaccurate predictions of the flow due to an imbalance between the opposing forces. Furthermore, conservation of physical properties is of high importance in accurately predicting turbulent and transitional regimes. A symmetry-preserving discretisation of the continuous operators in the Navier-Stokes equations will lead to conservation of mass, momentum and kinetic energy and is unconditionally stable [1]. It is therefore a suitable approach to predict these complex phenomena.

In this work, the symmetry-preserving method is extended to include the Lorentz force term, using the collocated grid arrangement of Ni et al. [2]. A second Poisson equation is solved to calculate the electric potential field and correct the current density to make it divergence free. The proposed solver is implemented in OpenFOAM and tested using several 2D and 3D benchmark cases at low Ha for which the analytical solutions are readily available. Global and local conservation of the aforementioned properties is monitored and compared to analytical results. Influence of the spatial discretisation on accuracy and stability is also examined. Finally, test cases with more complex geometries at higher Ha will be solved to compare our method to the ones available in OpenFOAM, showing its conservative properties and unconditional stability.

REFERENCES

[1] R.W.C.P. Verstappen and A. E. P. Veldman *Symmetry-preserving discretisation of turbulent flow.* Journal of Computational Physics 187.1 (2003): 343-368.

[2] M.J. Ni, R. Munipalli, N.B. Morley, P. Huang and M.A. Abdou, *A current density conservative scheme for incompressible MHD flows at a low magnetic Reynolds number. Part I: On a rectangular collocated grid system.* Journal of Computational Physics 227.1 (2007): 174-204.