SIMULATION OF THE INTERACTION OF SOLAR WIND/EARTH'S MAGNETOSPHERE USING AN ARTIFICIAL COMPRESSIBILITY APPROACH DEVELOPED FOR IDEAL MAGNETOHYDRODYNAMICS EQUATIONS

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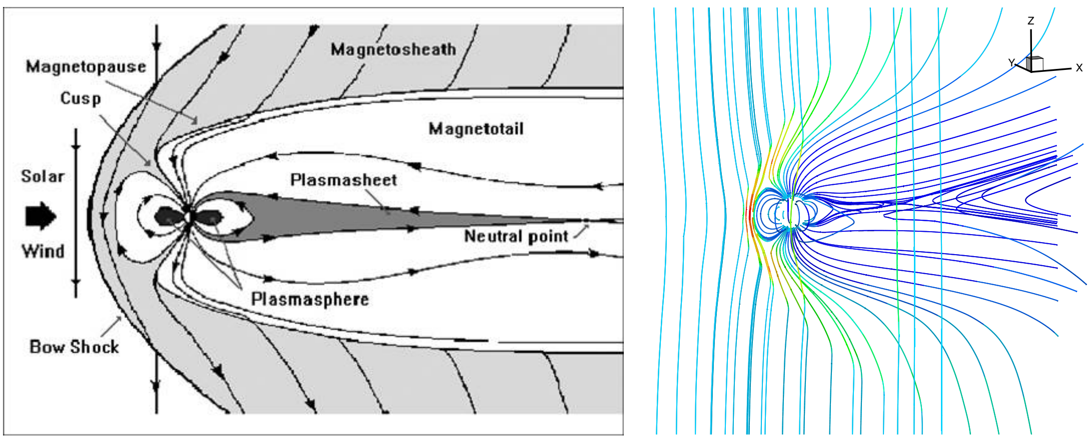
Ideal magnetohydrodynamics (MHD) simulations are known to have problems in satisfying the solenoidal constraint (i.e. the divergence of magnetic field should be equal to zero, $\nabla.\vec{B} = 0$. The simulations become unstable unless specific measures have been taken. In this thesis, a solenoidal constraint satisfying technique that allows discrete satisfaction of the solenoidal constraint up to the machine accuracy is presented and validated with a variety of test cases. Due to its inspiration from Chorin's artificial compressibility method developed for incompressible CFD applications, the technique was named as artificial compressibility analogy (ACA) approach.

It is demonstrated that ACA is a purely hyperbolic, stable and consistent technique, which is moreover easy to implement. Unlike some other techniques, it does not pose any problems of the sort that $\nabla.\vec{B}$ errors accumulate in the vicinity of the stagnant regions of flow. With these crucial properties, ACA is thought to be a remedy to the drawbacks of the most commonly used solenoidal constraint satisfying techniques in the littérature.

The upwind finite volume ideal Magnetohydrodynamics (MHD) solver was developed in COOLFluiD, the multi-physics object-oriented framework under development at the VKI. A thorough numerical verification of the ACA approach has been made on an increasingly complex suite of test cases. The results obtained with ACA and Powell's source term implementations are given in order to numerically analyse and verify ACA and compare the two methods and validate them with the results from literature. The final chapter is devoted to further validation of ACA performed with a variety of more advanced space weather-related simulations. In this chapter, a magnetic field splitting technique is presented to treat planetary magnetospheres, along with its application to ACA and Powell's source term approaches. This technique is utilized for obtaining the solar wind/Earth's magnetosphere interaction as illustrated in the figure.



(a) *(b)*

Figure 1: (a) Schematic view of the Interaction of Solar Wind/Earth's Magnetosphere (b) Computed density variation on magnetic field lines for the same test case (3D)