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The Virtual Element Method for the 3D Resistive Magnetohydrodynamic Model

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In this talk, we present the design and implementation of a Virtual Element Method for solving the Magnetohydrodynamics (MHD) 3-D model in the resistive regime, cf. [3]. The preliminary works were on the VEM for solving the 2-D MHD model [1, 2]. Magnetohydrodynamics describe the magnetic properties of electrically conducting fluids, such as plasmas and liquid metals. A magnetic field can induce a current in the fluid and this current polarizes the media and self-consistently changes the electro-magnetic fields. Consequently, the MHD model is a nonlinear combination of Maxwell's and fluid dynamics equations, and their computer resolution poses many formidable challenges and pitfalls to the numerical modeler. For example, spurious effects due to unphysical magnetic monopoles can appear in computer simulations if the divergence-free constraint $\text{div}\mathbf{B} = 0$ for the magnetic flux field $\mathbf{B}$ is not accurately preserved (possibly at the machine precision level) by the numerical method. Similar unphysical results may appear in numerical simulations if the incompressibility constraint is not properly satisfied by the fluid velocity $\mathbf{u}$. Using suitable de Rham complexes in the design of the VEM guarantees that both the magnetic flux field $\mathbf{B}$ and the fluid velocity $\mathbf{u}$ are divergence free. The convergence of the method is proved theoretically and confirmed by our preliminary numerical investigations.

REFERENCES

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