Contribution ID: **1216** Contribution code: **MOPS72** Type: **Poster Presentation**

Solving the Orszag-Tang vortex magnetohydrodynamics problem with physics-constrained convolutional neural networks

Monday, 20 May 2024 16:00 (2 hours)

The 2D Orszag-Tang vortex magnetohydrodynamics (MHD) problem is studied through the use of physics-constrained convolutional neural networks (PCNNs). The density and the magnetic field are forecasted, and we also predict magnetic field given the velocity field of the fluid. We examined the incorporation of various physics constraints into the PCNNs: absence of magnetic monopoles, non-negativity of density and use of only relevant variables. Translation equivariance was present from the convolutional architecture. The use of a residual architecture and data augmentation was found to increase performance greatly. The most accurate models were incorporated into the simulation, with reasonably accurate results. For the prediction task, the PCNNs were evaluated against a physics-informed neural network (PINN), which had the ideal MHD induction equation as a soft constraint. The use of PCNNs for MHD has the potential to produce physically consistent real-time simulations to serve as virtual diagnostics in cases where inferences must be made with limited observables.

Footnotes

Funding Agency

Los Alamos National Laboratory - Laboratory Directed Research and Development (LDRD)

Paper preparation format

LaTeX

Region represented

North America

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Session Classification: Monday Poster Session

Track Classification: MC5: Beam Dynamics and EM Fields: MC5.D13 Machine Learning