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NEURAL NETWORK BASED CLOSURES TO FLUID SYSTEMS TRAINED WITH KINETIC SIMULATIONS

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We develop a neural network based closure to the one-dimensional fluid moment equations, that allows us to carry out simulations of plasmas in intermediate collisional regimes. The neural network is trained to predict the heat flux of the plasma from its density, mean velocity and temperature, using data produced with kinetic simulations of the Vlasov-Poisson equation. We use a convolutional neural network with a V-Net like architecture, which allows it to capture non-local dependances, and results in a global closure. Data generation and data processing are designed with the aim of ensuring uniform accuracy on a wide range of Knudsen numbers and initial conditions. We carry out numerical experiments to assess the accuracy and generalization ability of the neural network based closure.

Our work relates to [3], that explores the ability of several models to learn a given closure like the Hammett-Perkins closure.By comparison, our method leverages data from kinetic simulations which allows the model to learn a new closure. A different approach for leveraging kinetic simulations was carried out in [2], where the authors construct a reduced model using machine learning.

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