Learning of viscosity functions in rarefied gas flows with physics-informed neural networks

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The prediction of non-equilibrium transport phenomena in disordered media is a difficult problem for conventional numerical methods. An example of such a challenging problem is the prediction of gas flow fields in the rarefied regime, where solving the Boltzmann equation is computationally too demanding. Physics-informed neural networks (PINNs) have been recently proposed an alternative, but remain close to the Boltzmann equation in terms of mathematical formulation. Furthermore, up until now, no systematic study of the impact of PINN designs on the performance of PINNs have been made. In this presentation, we will show how PINNs can be employed to predict the velocity field of a rarefied gas flow in a slit at increasing Knudsen numbers according to a generalized Stokes phenomenological model using an effective viscosity function. We found that activation functions with limited smoothness result in errors orders of magnitude larger than infinitely differentiable functions, and that the AdamW is by far the best optimizer for this inverse problem. The design was found to be robust from Knudsen numbers ranging from 0.1 to 10. Our findings stand as a first step towards the use of PINNs to investigate the dynamics of non-equilibrium flows in complex geometries.

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