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Moment closure problem: equation discovery and deep learning techniques applied to kinetic plasma simulations

Reduced order modelling (ROM) plays an important role in the descriptions of different plasma environments such as heliosphere, solar wind and beyond. ROMs can be obtained via analytical closures; however, such approaches are limited when distribution functions are far from Maxwellian and/or in weaker guide fields. To push the envelope of ROMs in plasmas we apply machine learning frameworks that seek to extract the relevant terms that need to be kept in the equations for moments (EoMs), identifying terms such as anisotropic pressure in the momentum equation. This is done systematically on several datasets generated via kinetic simulations: 1D Landau damping, 2D decaying turbulence, 2D magnetic reconnection. The sparse/symbolic regression techniques used include wSINDy and PDE-Net. We show examples of successful identification of EoMs. These approaches are compared with multi-layer perceptron trained to reconstruct the pressure tensor as a function of local lower-order moments. We show that the method is successful, assuming the test data comes from simulations with guide fields of comparable values to at least a few runs in the training dataset. Interestingly, accuracy of the predicted pressure tensor increases as we add extra runs corresponding to stronger guide fields. These results are promising for the development of global surrogate models for space plasmas that capture Finite Larmor Radius (FLR) effects.

Bibliography:
Laperre, B. et al 2022. Physics of Plasmas 29, 032706
Long, Z., 2018. PMLR, pp. 3208–3216.
Alves, E.P.„ 2022. Phys. Rev. Res. 4, 033192.

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