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Stiff-PINN: Physics-Informed Neural Network for Stiff Chemical Kinetics

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Recently developed physics-informed neural network (PINN) has achieved success in many science and engineering disciplines by encoding physics laws into the loss functions of the neural network, such that the network not only conforms to the measurements, initial and boundary conditions but also satisfies the governing equations. This work first investigates the performance of PINN in solving stiff chemical kinetic problems with governing equations of stiff ordinary differential equations (ODEs). The results elucidate the challenges of utilizing PINN in stiff ODE systems. Consequently, we employ Quasi-Steady-State-Assumptions (QSSA) to reduce the stiffness of the ODE systems, and the PINN then can be successfully applied to the converted non-/mild-stiff system. Therefore, the results suggest that stiffness could be the major reason for the failure of the regular PINN in the studied stiff chemical kinetic systems. The developed Stiff-PINN approach that utilizes QSSA to enable PINN to solve stiff chemical kinetics shall open the possibility of applying PINN to various reaction-diffusion systems involving stiff dynamics.