# Graph Neural Networks for Kinetic Simulations of a 1D Plasma Sheet Model

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In recent years, attempts have been made to combine existing plasma kinetic codes with machine-learning surrogate models, in order to obtain a computational speed-up. In this work, we explore the possibility of fully replacing the plasma physics simulator with a graph neural network-based simulator [1, 2]. We show that our model learns the kinetic plasma dynamics of the one-dimensional plasma model introduced by J. Dawson [3] (a predecessor of contemporary kinetic plasma simulation codes). We focus on this class of surrogate models given the similarity between their message-passing update mechanism and the traditional physics solver update, and the possibility of enforcing known physical priors into the graph construction and update. We assess the generalization capabilities of such a model regarding the emergence of well-known kinetic plasma processes, including plasma thermalization, electrostatic fluctuations about thermal equilibrium, and the drag on a fast sheet and on a Fourier mode (Landau damping). Additionally, we compare the performance against the original plasma model in terms of running time, conservation laws, and temporal evolution of key physical quantities. The limitations of the model are also discussed and possible directions for higher-dimensional surrogate models for kinetic plasmas are outlined.

**References**

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