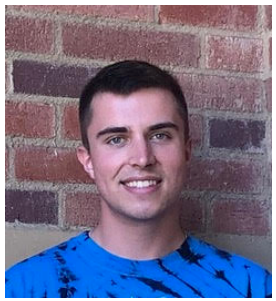
UCLA

Plasma Physics Seminar

Physics & Astronomy Building (PAB) Room 4-330
Via Zoom: https://ucla.zoom.us/j/92785449357?pwd=SVBTSko3bTdEUW03dzQwNks1Q2lKZz09
Friday, March 22, 2024 at 12:30PM
Lunch will be served at 12:00PM

Reconstructing Non-Linear Kinetic Plasma Dynamics From Sparse Measurements Using Physics-Informed Neural Networks

Zack Pine (UCLA)



Abstract: Accurately diagnosing and characterizing dynamics in laboratory experiments is essential for advancing basic plasma science and technology. There have been remarkable advances in modern plasma physics experiments—such as high repetition-rate high-power lasers and pulsed power systems—that are providing unprecedented amounts of highly-resolved spatial and temporal plasma measurements. However, the development of computational tools that can harness such spatially and temporally resolved measurements to enhance characterization of plasmas remains lacking. Emerging techniques from scientific machine learning are offering promising new tools that can address these challenges. In this work, we explore the potential of physics-informed neural networks (PINNs) to combine partial spatiotemporal measurements of plasma dynamics with fundamental plasma physics equations to reconstruct physically-consistent plasma quantites that were not measured in experiment. To understand the potential of PINNs, we test this approach on PIC simulation data of the nonlinear dynamics of the electrostatic two-stream instability. Our results show that PINNs can reconstruct the dynamics far more accurately than standard interpolation methods (including neural networks that do not incorporate prior knowledge about the physics of the system) for randomly sampled sparse data. We investigate how the reconstruction accuracy varies with the amount of measurement data and how it is impacted by data noise. Lastly, we use ensemble methods to show that PINNs can be used to optimally plan and design an experiment by informing which diagnostics to use and where/when measurements should be made to maximize the information collected in a plasma physics experiment.