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LLNL FESP Theory Highlights: April 2024

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LLNL FESP Theory Highlights: April 2024

Editor: Ben Dudson (Group Leader), on behalf of the LLNL Fusion Theory & Modeling group.

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Contents

Conference presentations

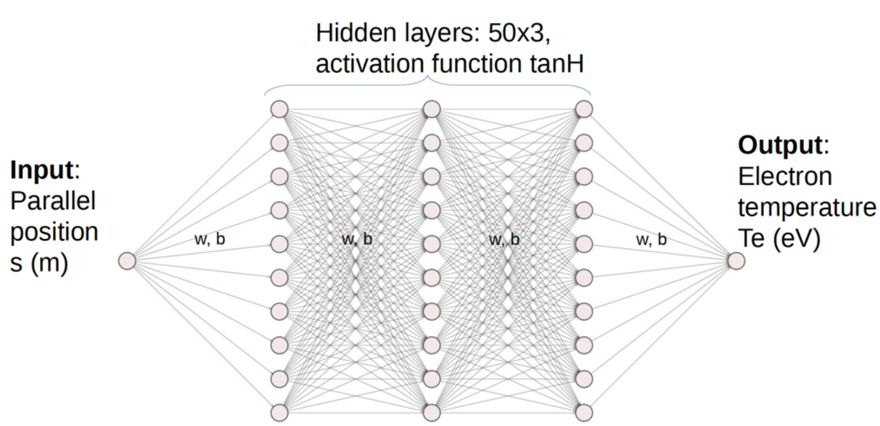
Menglong Zhao, Luning Sun, **Ben Zhu** "Applications of Physics Informed Neural Networks in Tokamak Edge Physics". Poster at the 2024 US-EU Transport Task Force Workshop, April 9-12, Asheville NC.

Physics Informed Neural Networks (PINNs) are neural networks that can approximate any set of partial differential equations in a 'mesh-free' manner, distinct from conventional finite difference/volume/element methods. We implemented PINNs to solve a 1D heat equation, to compare against UEDGE and test two applications:

1. Forward simulations: Solving the 1D steady state electron temperature equation (only Te for now) using PINNs without any data.
2. Inversion: Finding unknown terms, here the electron parallel thermal transport coefficient, using PINNs fitted to UEDGE results.

The flexibility of UEDGE and its python interface enable us to easily develop and test PINNs for solving plasma edge equations. Promising initial results were obtained using PyTorch default strategies; We are now exploring more advanced fitting methods.

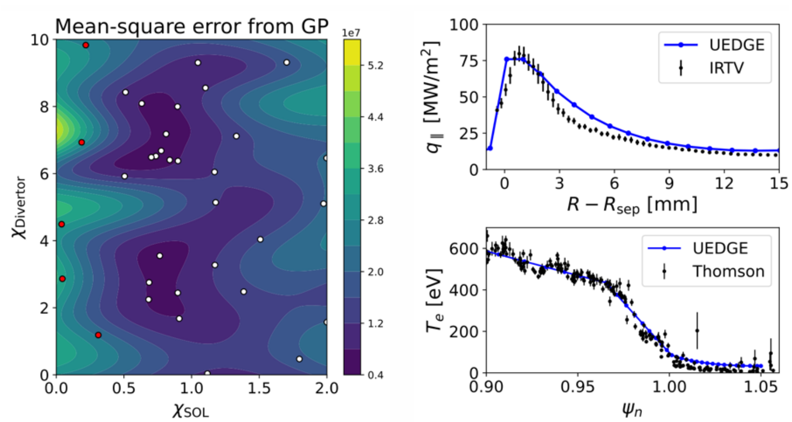
1D flux tube: $B\frac{\partial}{\partial s}\frac{1}{B}\left(q_{e\|}^{\mathrm{cond}} + \frac{5}{2}nT_e u_\|\right) = u_\| \frac{\partial}{\partial s}p_e + J_\| \cdot R_\|/(en) - Q^{T_e-T_i} + S_e^E$



Te (eV) is a continuous function in terms of s (m): $T_e = nn_\theta(s)$

Yichen Fu, **Benjamin Dudson**, Xiao Chen, **Maxim Umansky**, Filippo Scotti. “Statistical inference of anomalous thermal transport with uncertainty quantification in the plasma boundary”. Poster at the 2024 US-EU Transport Task Force Workshop, April 9-12, Asheville NC.

In this study, part of an ongoing LDRD project ”**Establishing an LLNL design hub for tokamak fusion reactor divertor systems**” (PI: B. Dudson), the crucial task of inferring anomalous cross-field transport coefficients from experimental data is addressed in fluid-based plasma boundary simulations with UEDGE. Here, we use an interpretive model for fast calculation, infer anomalous transport by comparing with measurements, and utilize Bayesian Optimization to automate fitting and perform Uncertainty Quantification.



Collaboration with General Fusion Inc.

L. Carbajal , A. Froese , C. Ribeiro , C. Dunlea , S. Howard , R. Ivanov , **M. Umansky , T. Rognlien** , and General Fusion Team. “Edge Modeling and Simulation of Plasma Injector (Pi3) Plasmas with Lithium Walls Poster: PP11.00037” APS-DPP 2023.

General Fusion (GF) is working towards commercial power generation through magnetized target fusion. The LLNL Fusion Theory and Modeling group is collaborating with GF through a Strategic Partnership Project (SPP, LLNL PI: M. Umansky), applying our CORSICA and UEDGE tools.

The Pi3 toroidal fusion device with lithium walls at GF is modeled in a joint project by GF and LLNL scientists.

- LLNL code **Corsica** is used for designing Pi3 MHD equilibria.
- LLNL edge transport code **UEDGE** is used for analysis of boundary plasma. Validation is by Langmuir probes and spectroscopic data.