Accelerated tokamak transport simulations via Neural-Network Based Regression of TGLF Turbulent Energy, Particle and Momentum Fluxes

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A tool that uses neural networks (NNs) to accurately predict first principles particle, energy, and momentum fluxes in tokamaks has been developed. The core of this tool is a multilayer NN that performs a nonlinear regression of the TGLF transport model. TGLF provides a fast and accurate approximation to the linear eigenmodes for gyrokinetic drift-wave instabilities. The input for the NN training consists of the same set of local dimensionless plasma input parameters as the original TGLF model. The NN is trained and tested on a large database of TGLF runs, which are based on the experimental conditions of existing DIII-D shots. For this purpose a new remote data acquisition technology, which automatically collects data for any TGLF run without having any effect on the performance of numerical simulations, has been developed. The NN has been integrated into TGLF, so that if the input parameters fall into the NN training domain, the result will be quickly computed, otherwise, the first principles calculation is performed, and the resulting data is stored for later updating the NN training. As more data is added to the database, the domain of parameters on which the NN is trained automatically expands, allowing the NN to be used on an ever growing range of parameters. Compared with TGLF results, it is found that the NN can accurately predict particle, energy, and momentum fluxes for both electrons and ions, as depicted for the electrons energy flux in the figure below. This new approach provides a computational speedup of over 5 orders of magnitude compared to the original calculation, which makes it ideal for scenario development simulations and real-time plasma control.
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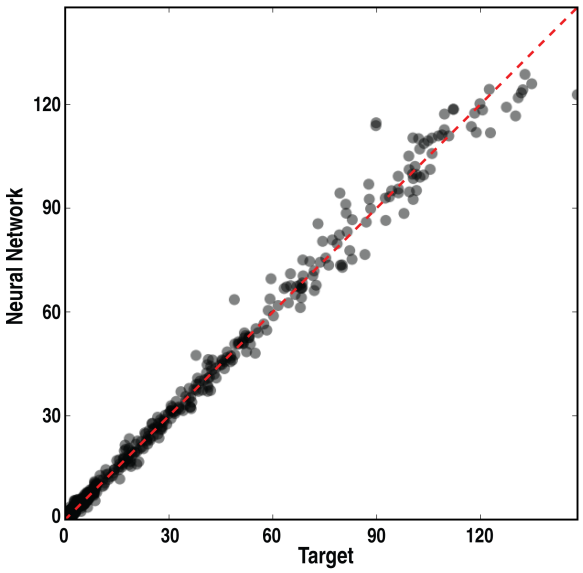
Electron Energy Flux



Comparison between electrons energy flux evaluated by the NN and TGLF. The regression plot shows that the NN is accurate, as the outputs are distributed along the red dashed line, which is the ideal value of the results.