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A deep learning-based model for the cross-scale instability in fusion plasma

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Plasmas and plasma-enabled technologies are pervasive in everyday life, but their nonlinear, multiscale behaviors bring challenges for understanding, modeling, and controlling these systems. Accurately revealing the physical mechanism of plasma may provide crucial information for the successful plasma control in real-time tokamak discharge. However, the computation demands a realistic description of system size and timescales remains challenging for many problems. With the emergence and development of artificial intelligence (AI) as well as deep learning (DL) algorithms, these changed, especially in fluid mechanics. In this report, we provide a deep learning-based surrogate model considering the predictions of multi-scale multi-mode instability in real-time conditions.

The surrogate models are developed based on tokamak plasma. In this research, the schematic diagram for the construction of models is defined. The surrogate models can be applied in predicting transport properties both with linear and nonlinear phases. With a further development, the models can predict the interaction of multi-scale multi-mode instability. The newly constructed surrogate models show the sufficient ability to reproduce the same simulation results. Furthermore, the newly DL model can accurately obtain the physical characteristics of MHD and micro-instability in tokamak with a computational cost of only a small amount of CPU time. Moreover, the DL-based models may play a vital role in the 'Intelligent Controlling'in tokamak device in future.

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