High-Temporal-Resolution MHD Stability Analysis Using Neural Network-Based Kinetic Profile Reconstructions on the COMPASS tokamak

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The temporal resolution of Thomson scattering (TS) diagnostics in tokamaks is fundamentally limited by the laser repetition rate, yielding a sampling rate of 4 × 30 Hz (~8 ms time step) on the COMPASS tokamak [1]. However, several diagnostics - such as soft X-ray (SXR) detectors, AXUV photodiodes, interferometry, or magnetic sensors - offer much faster sampling (up to MHz) and also measure plasma parameters correlated with TS profiles. The relationships between these fast diagnostics and TS T_e and n_e profiles are nonlinear and analytically impossible to express due to the incomplete knowledge of impurity ionization states and transport effects.

To overcome these limitations, artificial neural networks were trained on TS data to reconstruct electron temperature and density profiles from the fast diagnostic signals, achieving a temporal resolution up to the 3 μs and a reconstruction error of approximately 10%. The resulting profiles were subsequently used in peeling-ballooning MHD stability analysis of Edge Localised Modes (ELMs) using the MISHKA code [2]. The results show strong consistency with theoretical models, demonstrating that the implemented neural network-based reconstruction enables high-temporal-resolution studies of ELM and other dynamics in tokamak plasmas.

[1] P. Bilkova, *et al.*, *J. Instrum.* **13** (2018) C01024.

[2] G. T. A. Huysmans, *et al.*, *Phys. Plasmas* **8** (2001) 4292.

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