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# Identification of characteristic ELM evolution patterns with Alfven-scale measurements and unsupervised machine learning analysis

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Characteristic edge localized mode (ELM) evolution patterns are identified and measured at Alfven timescales with a multi-point beam emission spectroscopy (BES) diagnostic on NSTX/NSTX-U, and parameter regimes corresponding to the characteristic ELM evolution patterns are identified. The linear peeling-ballooning stability boundary expresses an onset condition for ELMs, but ELM saturation mechanisms, filament dynamics, and multi-mode interactions require nonlinear models. Validation of nonlinear ELM models requires fast, localized measurements on Alfven timescales. Recently, we investigated characteristic ELM evolution patterns with Alfven-scale measurements from the NSTX-U beam emission spectroscopy (BES) system [1]. We applied clustering algorithms from the machine learning domain to ELM time-series data. The algorithms identified two or three groups of ELM events with distinct evolution patterns. In addition, we found that the identified ELM groups correspond to distinct parameter regimes for plasma current, shape, magnetic balance, and density pedestal profile [1]. The ob-served evolution patterns and corresponding parameter regimes suggest genuine variation in the underlying physical mechanisms that influence the evolution of ELM events and motivate nonlinear MHD simulations. Here, we review the previous results for ELM evolution patterns and parameter regimes, and we report on a new effort to explore the identified ELM groups with 2D BES measurements and nonlinear MHD simulations. Finally, we discuss opportunities to leverage machine learning tools in the data-rich fusion science field.
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[1] D. R. Smith et al, Plasma Phys. Control. Fusion 58, 045003 (2016)

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