Real-time control of multiple MHD instabilities on TCV by ECRH/ECCD

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Highly localized deposition of ECRH/ECCD is particularly suited for MHD control, in particular when combined with real-time beam orientation and power control capabilities. The powerful (4.5MW) and flexible (7 steerable launcher) EC system on TCV has recently been complemented by an equally flexible digital real-time control system with the aim of developing and testing integrated MHD control methods [1]. Sawtooth pacing is one such method [2]. The crash time of stabilized sawteeth can be precisely controled by removing the EC power at a given time after the last sawtooth crash, causing the crash to occur at a short and reproducible time thereafter. This control strategy is combined with efficient neoclassical tearing mode (NTM) preemption by depositing power at the mode rational surfaces only during a short time synchronized with the island-seeding sawtooth crash. If an NTM appears nevertheless, full power is applied to stabilize the mode. The real-time steerable launchers have also been employed to stabilize fully saturated NTMs and to investigate the precise requirements for deposition localization for full island stabilization. Finally, though ELM dynamics is markedly different, recent results show that ELM pacing is possible using a similar control technique as used for sawtooth pacing. In this case, edge EC power is removed after each ELM, and is reapplied after a programmable time interval. The ELM period can be real-time controlled by adjusting the length of this interval. While the overall trend conforms to the increase of ELM frequency with increasing power, this technique provides a means to significantly regularize the ELM cycle.