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OV/4-3: Energetic Particle Instabilities in Fusion Plasmas

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A remarkable progress was made in diagnosing energetic particle instabilities on present-day machines and in establishing a theoretical framework for describing them. This overview presents a point-by-point comparison between the much improved diagnostics of Alfvén Eigenmodes (AEs) and modelling tools developed world-wide, and outlines progress in interpreting the observed phenomena. A multi-machine comparison is presented giving a fair idea on the performance of both diagnostics and modelling tools for different plasma conditions. On JET equipped with 2D gamma-ray camera and interferometry, core-localised TAEs were detected causing redistribution of fast ions from inside the q=1 radius to outer plasma region followed by monster sawtooth crashes. TAE modelling using the HAGIS code showed a good agreement with the measured re-distribution and its effect on sawteeth. On DIII-D and AUG, ECE-imaging provides detailed measurements of amplitude and structure of AEs. A successful modelling was performed using the ORBIT code for reproducing the anomalously flat beam profiles on DIII-D. In AUG, a monitoring of the fast-ion redistribution and losses with an array of scintillators and fast-ion D-alpha spectroscopy has shown how a radial chain of overlapping AEs enables the transport of fast-ions from the core to the fast-ion loss detector. On NSTX, beam-driven AEs were observed in the form of "avalanches"consisting of coupled modes with strong frequency chirp. These modes caused ˜10% drops in the neutron rate explained by effects of decrease in the beam energy and beam losses resulting from the interaction with TAE. A nonlinear model for near-threshold beam-driven instabilities has successfully encompassed many of the temporal characteristics of AEs seen in experiments. A steady-state nonlinear mode saturation and bursts of mode activity were found to be associated with both the strength and type of relaxation process in the phase-space region surrounding the resonance of the distribution function. An extension of the model to modes with a frequency sweep comparable to the starting frequency opened the opportunity for understanding the chirping modes in DIII-D, MAST, NSTX, START, and LHD. Finally, this presentation will outline expectations for ITER based on our present knowledge. This work was funded by the RCUK Energy programme and EURATOM.

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