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Alfvén Eigenmodes and Fast Ion Loss in the DIII-D and ASDEX-Upgrade Tokamaks[1]

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Newly obtained measurements of the fast ion profile, internal structure of Alfvén eigenmodes (AEs), and associated fast-ion losses reveal important details of the interplay between fast ion dynamics and AE activity on the DIII-D and ASDEX-Upgrade tokamaks. Surprisingly, fast ion losses are observed to span a broad region of energy and pitch angle, indicating that a significant fraction of the energetic particle phase space interacts with the modes and are lost to the wall. Coherent losses of energetic ions at Alfvén eigenmode (AE) frequencies clearly identify the role of AEs in the loss mechanism. These results were enabled by new diagnostic capabilities that provide a comprehensive picture of the phase space dynamics of the wave-particle interactions, including detailed 1D and 2D confined fast ion profiles and global eigenmode structures. The observed modes consist of multiple reversed-shear Alfvén eigenmodes (RSAEs), toroidicity induced Alfvén eigenmodes (TAEs), and the recently discovered beta induced Alfvén acoustic eigenmodes (BAAEs). Coherent losses of beam ions measured by scintillator detectors in both devices are predominantly due to TAEs while both RSAEs and TAEs are observed to cause large coherent losses of fast ions in AUG discharges with ion cyclotron heating. Concomitant with these losses is a measured central fast ion depletion, where as much as 50% of classically predicted fast ion population is lost or redistributed. Key aspects of the measurements including eigenmode structure, stability and fast ion transport are reproduced using a variety of tools including the nonlinear initial value codes M3D and TAEFL as well as the linear eigenvalue solver NOVA-K combined with orbit following codes (ORBIT, HAGIS).

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