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Alfvén instabilities and energetic particle physics in toroidal plasmas[1]

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Modeling capabilities and experimental diagnostics for energetic particle-driven Alfvén instabilities have advanced significantly in recent years. Simulation tools now range from rapidly applied reduced-dimensionality models and hybrid fluid particle models to more comprehensive gyrokinetic approaches. Alfvén mode theory has been applied not only to tokamaks, but also to stellarators and reversed field pinches. Current diagnostic techniques allow direct imaging of the mode structure, fast ion density and loss patterns at the plasma edge, allowing theory/experiment comparisons in greater depth than previously possible. Examples from a variety of tokamak, stellarator and reversed field pinch experiments and the associated theory will be described. These activities are preparing the way for future ignited devices, such as ITER, where energetic alpha particles will provide the dominant plasma heating mechanism. High fidelity models of alpha behavior will be required for predicting their effects on the alpha heating profile, non-diffusive transport, nonlinear feedback loops and localized wall heat loads; in addition, understanding Alfvén spectral emissions can provide diagnostic opportunities. Projections of the current models to ITER and future physics needs will be discussed.

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