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Predictions of alpha-particle and neutral-beam heating and transport in ITER scenarios

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We present predictions of the ITER fusion-alpha and neutral-beam-injection (NBI) ion density and power-deposition profiles using a stiff transport critical gradient model (CGM) for Alfvén eigenmode (AE) transport in various ITER scenarios. In a burning plasma such as planned in ITER, deposited heat from fusion-born 3.5 MeV alpha particles provides most of the power needed to sustain fusion. Under current plans, high-energy (1MeV) neutral beam injected (NBI) ions will provide much of the remaining steady-state power. Both processes rely on energetic ions slowing down through collisions with electrons, depositing most of their energy into central plasma heat before being lost. Moreover, edge loss of inadequately slowed EPs poses a risk to plasma-facing components, particularly if such losses are concentrated in intermittent bursts. Looking principally at AE transport, the greatest identified risk, we will show that lower current and reversed-shear ITER scenarios show a decrease in EP confinement. We also show that increasing the NBI fraction of auxiliary heating degrades confinement for both the alpha particles and beam ions. The time-averaged EP profile prediction tools developed for this study have been verified against first-principles nonlinear simulations [1,2] and validated against a beam-heated DIII-D discharge [3]. A new fast computation of the critical gradient [4] eases integration into whole device modeling (WDM) frameworks. Also, a new quasilinear time-dependent transport model is used to investigate transport intermittency.

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