A critical gradient model for energetic particle transport from Alfven eigenmodes: GYRO verification, DIII-D validation, and ITER projection

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Local nonlinear gyrokinetic code GYRO [1] simulations of energetic particle driven low-n Alfven eigenmodes embedded in high-n microturblence have motivated a local critical gradient model (CGM) for stiff energetic particle (EP) transport from Alfven eigenmodes (AEs). The critical gradient in the EP density (or pressure) gradient identified by the local linear low-n AE growth exceeding the ion temperature gradient and trapped electron mode (ITG/TEM) linear rate at the same low-n was first found in GYRO simulations of ITER fusion alpha driven AEs [2]. This recipe for the CGM has again been verified and made more precise by recent nonlinear GYRO simulations of a well studied neutral beam injected (NBI) DIII-D discharge (146102)[3] where about half the fast ions are lost from the inner half radius by AE induced transport. This CGM incorporated in the ALPHA EP density transport code, used in a previous ITER projection of AE fusion alpha losses [4], was validated with the transported NBI pressure profile found to be in good agreement with DIII-D experimental fast ion pressure profiles[5]. Simulations using a recently developed kinetic (energy dependent) radial EP transport code EPtran[6] illustrate the importance of EP drift orbit broadening of the critical gradient profile. Passive EP transport from high-n ITG/TEM turbulence is represented by the Angioni model[7].

A key focus of the new work to be presented is a generalization of the ALPHA code and the CGM to include simultaneous AE drive from (and transport of) fusion alphas and 1 Mev NBI EPs in a projection of ITER EP losses.

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