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A critical gradient model for energetic particle transport from Alfven eigenmodes: GYRO verification, DIII-D validation, and ITER projection[1]

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Local nonlinear gyrokinetic code GYRO simulations of energetic particle driven low-n Alfven eigenmodes embedded in high-n microturbulence motivate a local critical gradient model (CGM) for stiff energetic particle (EP) transport from Alfven eigenmodes (AEs). The simulations show unbounded EP transport when the local linear low-n AE growth rate exceeds the ion temperature gradient and trapped electron mode (ITG/TEM) rate at the same low-n[1]. This linear rate condition for the critical EP density gradient is again verified by new nonlinear GYRO simulations of a well-studied neutral beam injected (NBI) DIII-D discharge (146102) where about half the fast ions are lost from the inner half to the outer half radius by AE induced transport. The CGM is revised to accounted for the small effect of ExB shear stabilization. This CGM incorporated in the ALPHA EP density transport code, used in a previous ITER projection of AE fusion alpha loses[2], is validated by the EP pressure profile in good agreement with the DIII-D experimental fast ion pressure profile[3]. A beam-like slowing down EP distribution in GYRO was used to find the AE linear rates. Non-local EP drift orbit broadening of the local critical gradient profile was found to be important in the DIII-D validation (but not in ITER projections)[4]. A two-EP-species CGM to include simultaneous AE drive from (and transport of) fusion alphas and 1 Mev NBI EPs is used for a revised projection of ITER EP losses.

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[3] R.E. Waltz, E.M. Bass, W.W. Heidbrink, and M.A, VanZeeland, Nucl. Fusion 55, 123002 (2015)
[4] H. Sheng and R.E. Waltz, Nucl. Fusion 56, 056004 (2016)

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