Gyrokinetic simulations of mesoscale energetic particle-driven Alfvénic turbulent transport embedded in microturbulence

E. M. Bass and R. E. Waltz

General Atomics, P.O. Box 85608, San Diego, California 92186-5608
e-mail: bassem@fusion.gat.com

(Received

ABSTRACT

Energetic particle (EP) transport from local high-n toroidal Alfvén eigenmodes (TAEs) and energetic particle modes (EPMs) is simulated with a gyrokinetic code. Linear and nonlinear simulations have identified a parameter range where the longwave TAE and EPM are unstable alongside the well-known ion-temperature-gradient (ITG) and trapped-electron-mode (TEM) instabilities. A new eigenvalue solver in GYRO facilitates this mode identification. States of nonlinearly saturated local TAE/EPM turbulent intensity are identified, showing a “soft” transport threshold for enhanced energetic particle transport against the TAE/EPM drive from the EP pressure gradient. The very long-wavelength (meso-scale) TAE/EPM transport is saturated partially by nonlinear interaction with microturbulent ITG/TEM-driven zonal flows. Fixed gradient length, nonlinearly saturated states are accessible over a relatively narrow range of EP pressure gradient. Within this range, and in the local limit employed, TAE/EPM driven transport more closely resembles drift-wave microturbulent transport than “stiff” ideal MHD transport with a clamped critical total pressure gradient. At a higher, critical EP pressure gradient, fixed-gradient nonlinear saturation fails: EP transport increases without limit and background transport decreases. Presumably saturation is then obtained by relaxation of the EP pressure gradient to near this critical EP pressure gradient. If the background plasma gradients driving the ITG/TEM turbulence and zonal flows are weakened, the critical gradient collapses to the TAE/EPM linear stability threshold. Even at the critical EP pressure gradient there is no evidence that TAE/EPM instability significantly increases transport in the background plasma channels.

PACS Nos.: 52.35Ra, 52.25Fi, 52.30Gz, 52.55Fa, 52.65Ti