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Dynamic Modeling of Step-wise Transport Barrier Formation in DIII-D NCS Discharges

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The GLF23 model [1] is used to dynamically follow bifurcations in the energy and momentum confinement in DIII–D NCS discharges [2]. Here, the temperatures and toroidal velocity profiles are evolved while self-consistently computing the effect of $E \times B$ shear stabilization during the formation and expansion of internal transport barriers. The barrier is predicted to form in a step-wise fashion with successive transitions to improved confinement states. This is consistent with experimental data where spontaneous jumps in the core electron and ion temperature and toroidal rotation velocity have been observed [3,4]. In the simulations, the transitions are governed by the balance between $E \times B$ shear stabilization and ITG instability and are independent of the local rational q-value. A precursor to each transition to improved confinement is also clearly evident with a characteristic dip in the temperature and toroidal velocity. At each localized transition, the sign of the $E \times B$ shear rate γ_E reverses from negative to positive values. The precursor is associated with a transient increase in thermal transport and toroidal viscosity as γ_E passes thru zero. The jump to improved confinement occurs when γ_E becomes positive and exceeds the predicted maximum linear growth rate. The profiles continue to evolve with transitions at successively larger radii as the internal barrier expands and finally reaches steady-state.

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