Global gyrokinetic simulation of toroidal momentum transport

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Recent results of both turbulence-driven and neoclassical momentum transport from our global gyrokinetic simulations with experimental plasma parameters are reported. It is found that a significant off-diagonal, inward component of toroidal angular momentum flux is driven during the transient phase of turbulence development, which is after the nonlinear saturation of the ITG instability, but before a well developed steady state. This inward momentum flux pumps the toroidal momentum from the outer region to the core while maintaining approximately global momentum conservation, resulting in a change in toroidal rotation with a magnitude of a few percent of the local thermal velocity. The off-diagonal flux, observed in various situations, with or without mean **E**x**B** shear flow, and with or without toroidal rotation as well as rotation shear, appears to be robust. It is anticipated that this "pumping" effect may lead to the built-up of an experimentally relevant rotation profile when there is a momentum source at the edge; but a true demonstration may require an edge momentum source to be implemented in future simulations in transport time scale. Moreover, this transient momentum flux is characterized by a spatio-temporal bursting behavior, along with the turbulence fluctuations and the ion heat flux. The simulation results also imply possible coupling between the momentum flux and the ion particle flux, though the later is small. On the other hand, the relatively low level residual momentum flux in the long-time steady-state appears to be mostly diffusive. Also examined is the ratio of the effective toroidal momentum and ion thermal diffusivities. For neoclassical transport, our simulations also show that the ion temperature gradient can drive a significant inward momentum flux. However, the overall neoclassical contribution to the momentum transport is small when compared to the experimental levels of NSTX and DIII-D discharges. This work was supported by U.S. DOE Contract DE-AC02-76-CH03073 and the SciDAC GPS-TTBP project.