DPP15-2015-001630

Abstract for an Invited Paper
for the DPP15 Meeting of
the American Physical Society

Torque-consistent 3D force balance and optimization of non-resonant fields in tokamaks

JONG-KYU PARK, Princeton Plasma Physics Laboratory

A non-axisymmetric magnetic perturbation in tokamaks breaks the toroidal symmetry and produces toroidal torque, which is well known as neoclassical toroidal viscosity (NTV) effects. Although NTV torque is second order, it is the first-order change in the pressure anisotropy that drives currents associated with local torques and thereby modifies the field penetration in force balance. The force operator becomes non-Hermitian, but can be directly solved using parallel, toroidal, and radial force balance, leading to a modified Euler-Lagrange equation. The general perturbed equilibrium code (GPEC), which has been successfully developed to solve the modified Euler-Lagrange equation, gives the torque-consistent 3D force balance as well as self-consistent NTV torque. The self-shielding of the torque becomes apparent in the solutions in high β, which was implied in recent MARS-K applications [1]. Furthermore, the full response matrix including the torque in GPEC provides a new and systematic way of optimizing torque and non-resonant fields. Recently the optimization of 3D fields for torque has been actively studied using the stellarator optimizing tools [2], but the efficiency and accuracy can be greatly improved by directly incorporating the torque response matrix. There are salient features uncovered by response with the torque, as the response can become invisible in amplitudes but only significant in toroidal phase shift. A perturbation in backward helicity [3] is an example, in which NTV can be induced substantially but quietly without measurable response in amplitudes. A number of other GPEC applications will also be discussed, including the multi-mode responses in high-β tokamak plasmas and the new non-axisymmetric control coil (NCC) design in NSTX-U. This work was supported by DOE Contract DE-AC02-09CH11466.

[1] Z. R. Wang, M. Lanctot, Y. Liu, J.-K. Park et al., Phys. Rev. Lett. **114,** 145005 (2015)
[2] S. Lazerson, J.-K. Park et al., Plasma Phys. Controlled Fusion, in Press (2015)
[3] J.-K. Park, Y. M. Jeon et al., Phys. Rev. Lett. **111**, 095002 (2013)