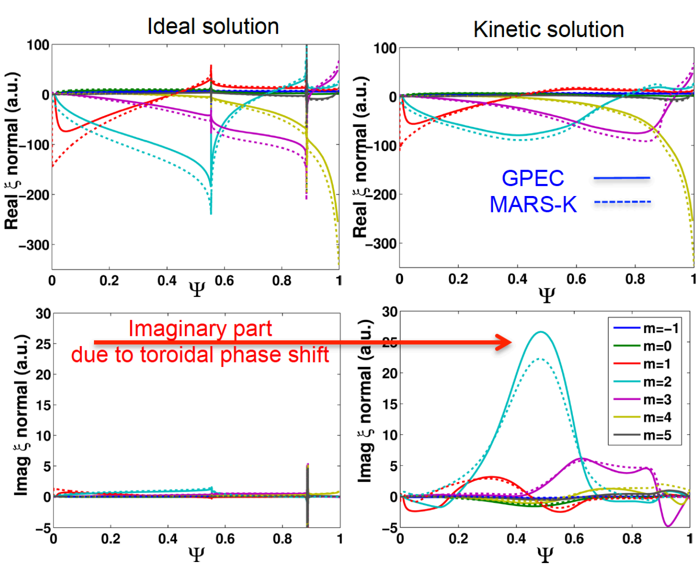
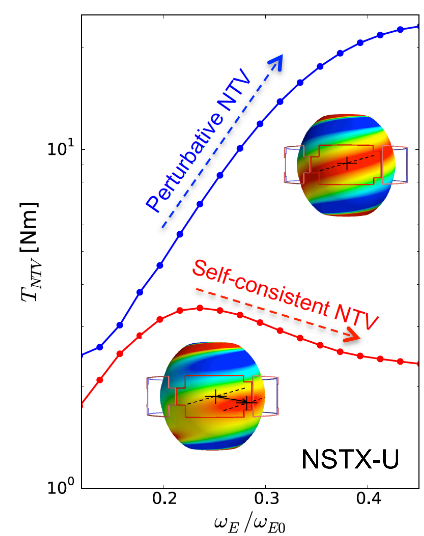
Self-consistent NTV formulation in GPEC yields torque response matrix that entirely redefines NTV optimizing process in tokamaks (J.-K. Park et al., Princeton Plasma Physics Laboratory)

- General Perturbed Equilibrium Code (GPEC)
  - Directly solves non-self-adjoint general force balance: $\delta\vec{F} = \delta\vec{j}\times\vec{B} + \vec{j}\times\delta\vec{B} - \vec{\nabla}\delta p - \vec{\nabla}\cdot\delta\vec{P} + \delta\vec{F}_g = 0$
  - Integrates energy and torque on the general force balance: $2\delta W + i\frac{\tau_\varphi}{n} = -\int\vec{\xi}\cdot\delta\vec{F}$
  - Torque by drift-kinetic $\vec{\nabla}\cdot\delta\vec{P}$ in non-axisymmetry is included for the first-order equilibrium as well as the second-order transport, yielding self-consistent NTV and torque response matrix: $\tau_\varphi(\psi) = \vec{\Phi}^\dagger\cdot\vec{T}(\psi)\cdot\vec{\Phi} = \vec{C}^\dagger\cdot\vec{T}_C(\psi)\cdot\vec{C}$
  - Torque response matrix contains all the information for NTV profile achievable by 3D field $\vec{\Phi}$ or given 3D coils $\vec{C}$, and thus immediately provide answers for non-linear NTV optimization problems through its eigenmode structure

Benchmark between GPEC vs. MARS-K, showing toroidal phase-shift in plasma response



NTV self-shielding by currents associated with torque, when model rotation increases



Core NTV optimization by GPEC torque response matrix vs. iterative IPECOPT method