Turbulence Update

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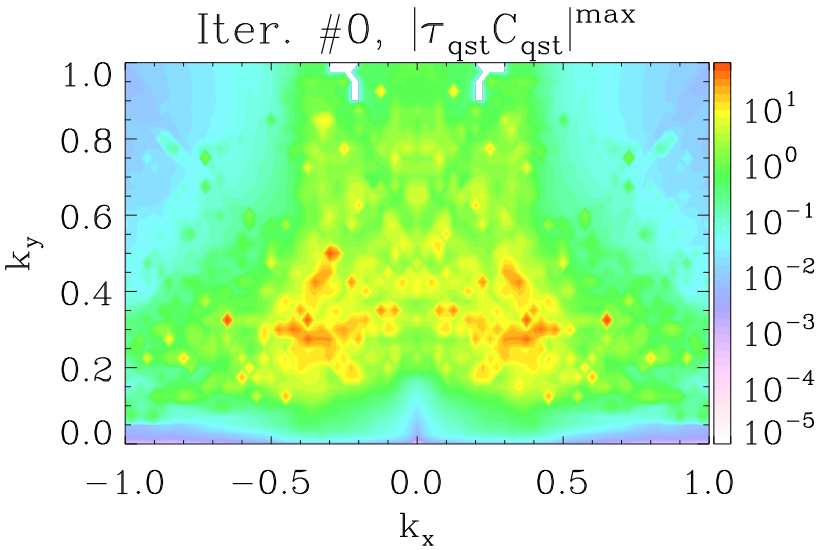
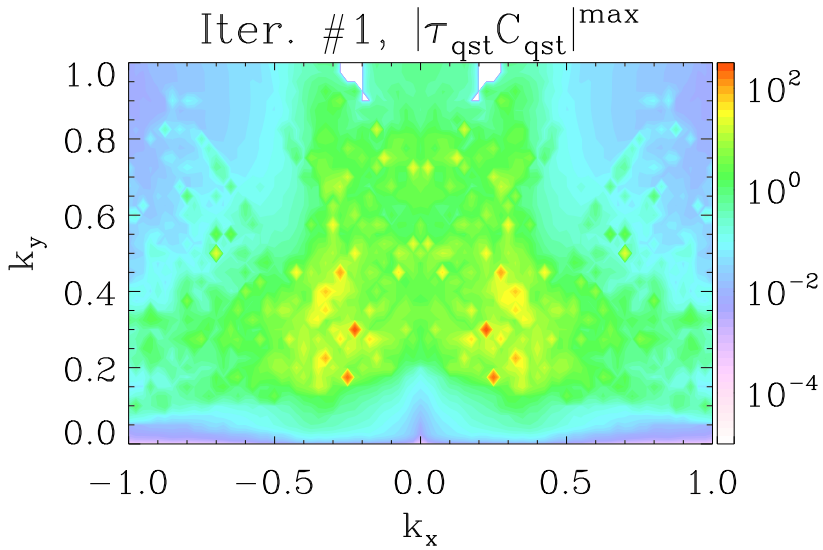
Improvements in PTSM3D workflow:

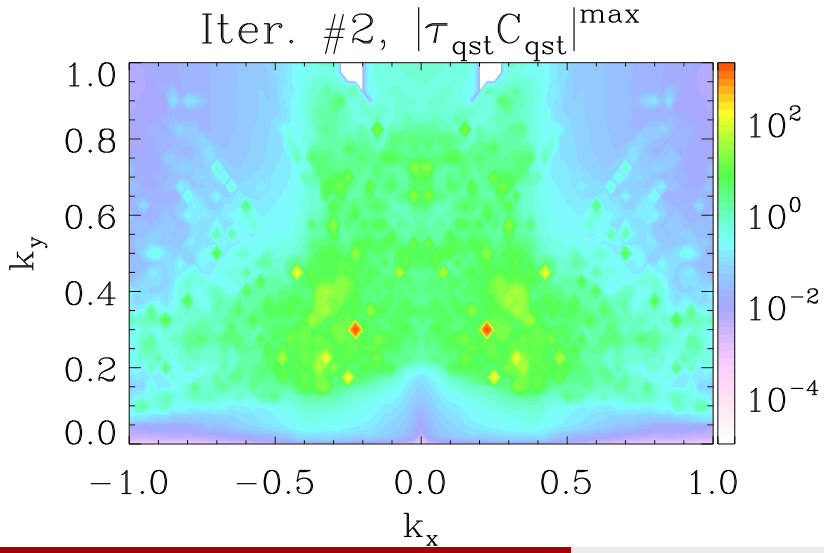
- The PTSM3D and Stellopt workflow has been unified with vmec2sfl (generates straight field line coordinates, based off code by M. Landreman)
  - Now just one version of PTSM3D, which uses vmec2sfl
  - Stellopt calls vmec2sfl as a library, replaces GIST
  - Eliminates sources of error arising from having different versions of codes
- Test case: HSX-QHS, vary $m = 0, \pm 1, \pm 2, \pm, \pm 4$, $n = 1, 2, 3, 4$ boundary coefficients with PTSM3D as sole target

QHS optimization

$$\langle \tau C \rangle : 2.17 \rightarrow 2.83 \rightarrow 3.40$$







- Non-zonal triplets still emphasize singular resonance
- After 2 iterations, optimizer falls into local minimum, cannot escape

PTSM3D target overly sensitive

- Precision lost when writing wout file, reflected in $\langle \tau C \rangle$

$$\langle \tau C \rangle_{\text{stellopt}} : 2.17 \rightarrow 2.83 \rightarrow 3.40$$
$$\langle \tau C \rangle_{\text{wout}} : 2.11 \rightarrow 2.68 \rightarrow 3.86$$

- τ_{pst} extremely sensitive to small changes due to resonant denominator:

$$\tau_{pst} = \frac{1}{i\left(\bar{\omega}_t + \Delta\omega_t + \bar{\omega}_s + \Delta\omega_s - \bar{\omega}_p^* - \Delta\omega_p^*\right)}$$

- $\bar{\omega}$ "true" frequency, $\Delta\omega$ represents eddy damping ($i\alpha k^2$) *numerical noise*
- Noise can lead to cancellation and resonance, over-emphasizing triplet correlations

Methods for model/optimizer improvement

- Gaussian eigenmode ansatz sensitive to numerical noise, replace with actual eigenvalue calculation
  - Underway, use SLEPc package
  - Should lead to a much more robust method
- Resonances are still most likely physical in nature and can lead to optimizers getting stuck in local minima. Possible refinements:
  - Alternate with τ^{-1} and τC as targets
  - Remove resonant modes from target after certain threshold
  - Vary model input parameters and average τC response over inputs (smooths space)