Turbulence Optimization Report

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Turbulence Optimization

- Possible avenues for achieving turbulence optimization:
  - Reduce linear instability growth rates (Mynick *et al.*)
  - Reduce overlap of mode trapping regions and bad curvature regions (Proll *et al.*)
  - **Increase amount of energy transferred to from unstable to stable modes/dissipation** (Hegna, Terry and Faber, PoP, 2018)
- Key idea: energy transferred between three modes in nonlinear three-wave coupling moderated by nonlinear correlation time $\tau = (\omega_3 + \omega_2 - \omega_1^*)^{-1}$ and coupling coefficient C: $\frac{\partial E}{\partial t} \propto \tau C$
- τ, C depend on linear drift-wave physics and energy-transfer (zonal vs. non-zonal)
- With three-field fluid model for ITG-adiabatic electrons, examine effect of changes in plasma boundary to $\langle \tau C \rangle$ (`PTSM3D`)

Optimization parameters

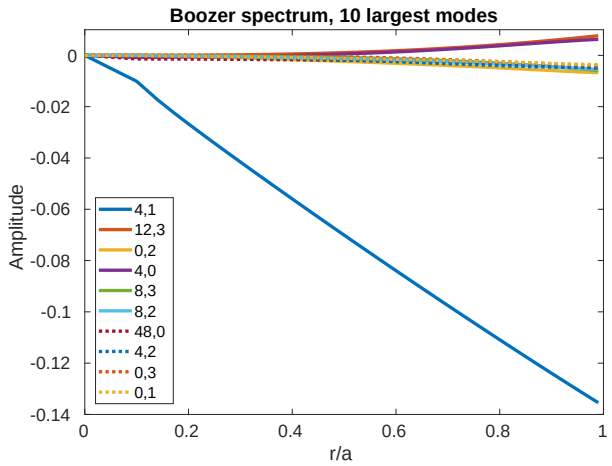
Key:

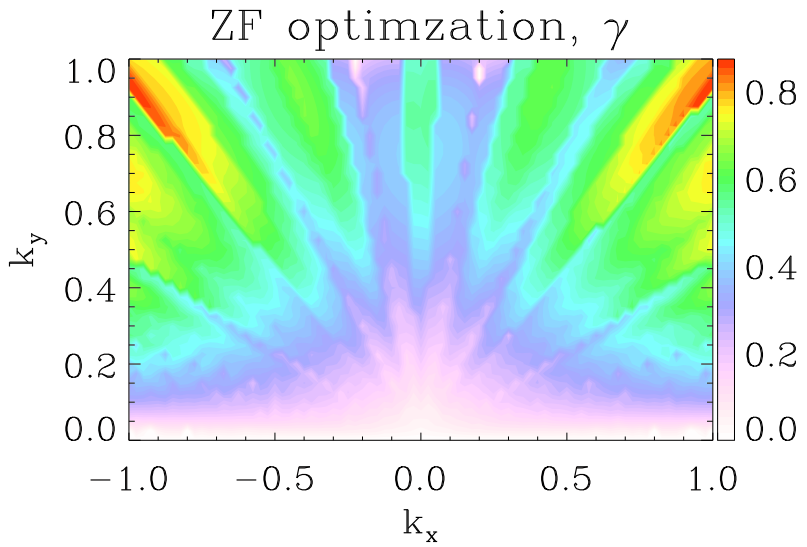
- "QHS-good": HSX QHS equilibrium reconstruction, including coil ripple
- "QHS-smooth": QHS equilibirum with only without coil ripple
- BC: VMEC boundary coefficient
- ZET: Zonal-flow-mediated energy transfer
- NZET: Non-zonal-mode-mediated energy transfer

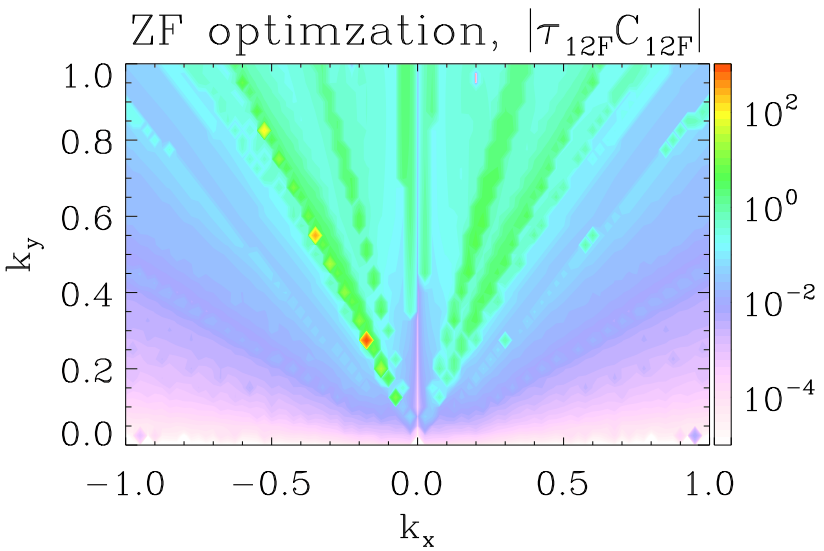
Set #	Target	Start Point	Free Parameters	$\langle \tau C \rangle_f \,/\, \langle \tau C \rangle_i$
1	ZET	QHS-good	First 48 BCs	7.73
2	NZET	QHS-good	First 48 BCs	2.42
3	ZET	QHS-smooth	First 68 BCs	1.69
4	NZET	QHS-smooth	First 68 BCs	2.93

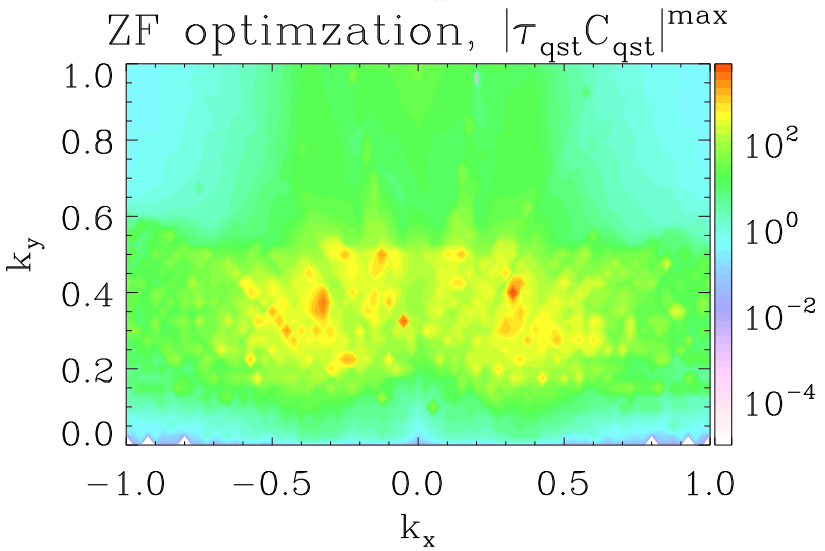
QHS, Zonal Flow Energy Transfer

$$\langle \tau C \rangle_Z^f / \langle \tau C \rangle_Z^i = 7.73$$









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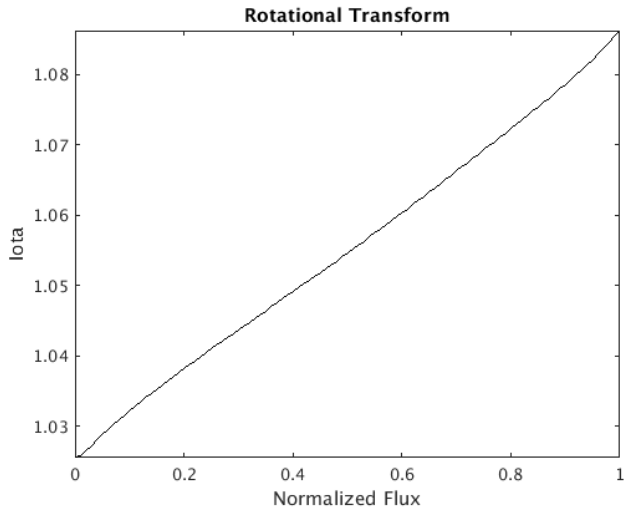

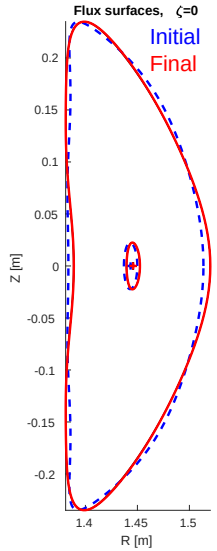

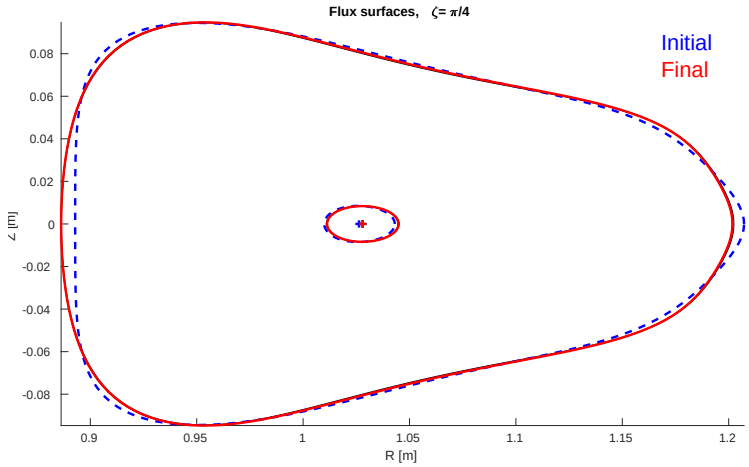

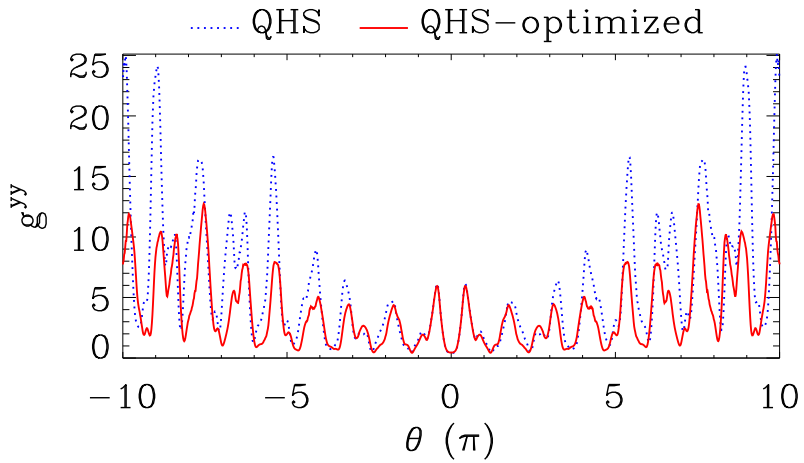

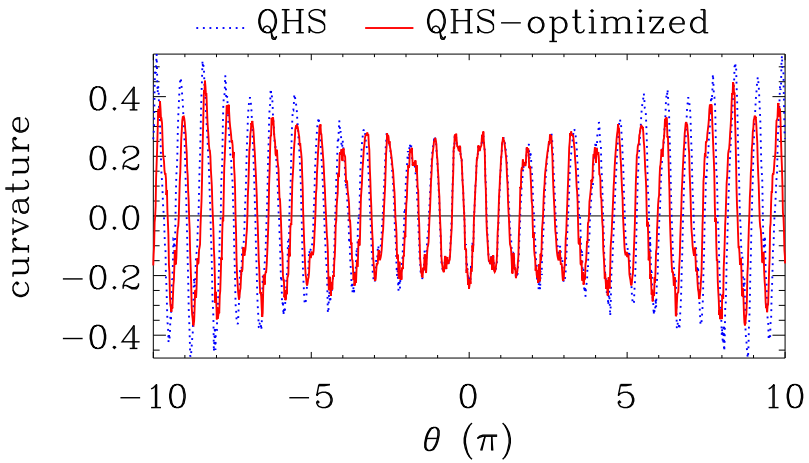

QHS, Zonal Flow Energy Transfer

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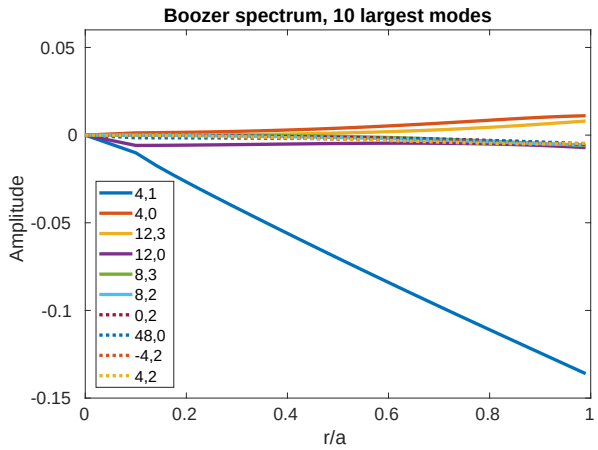

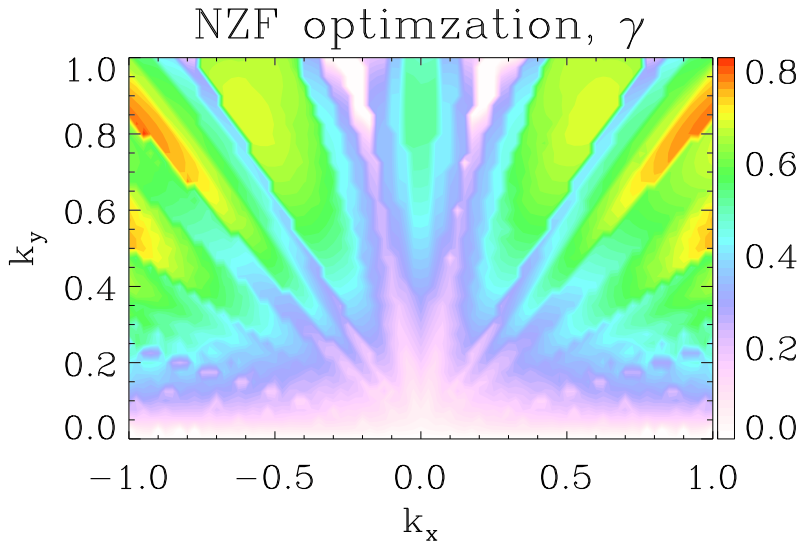

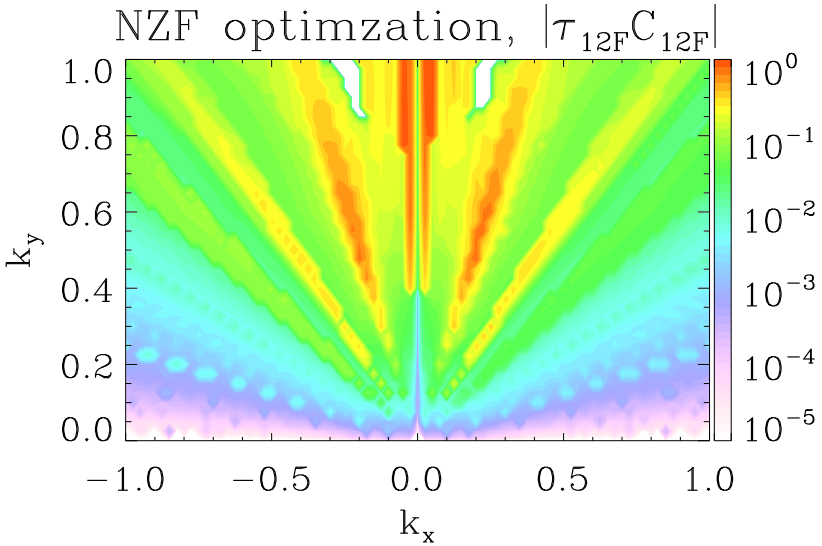

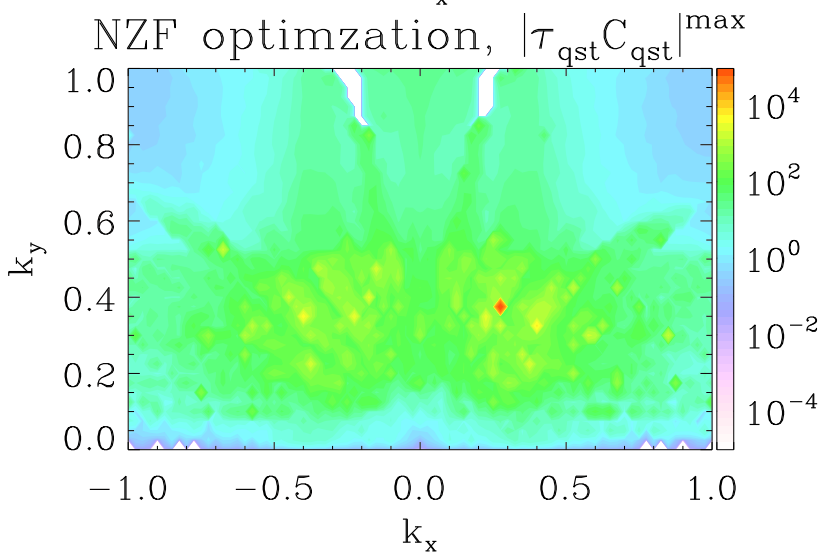

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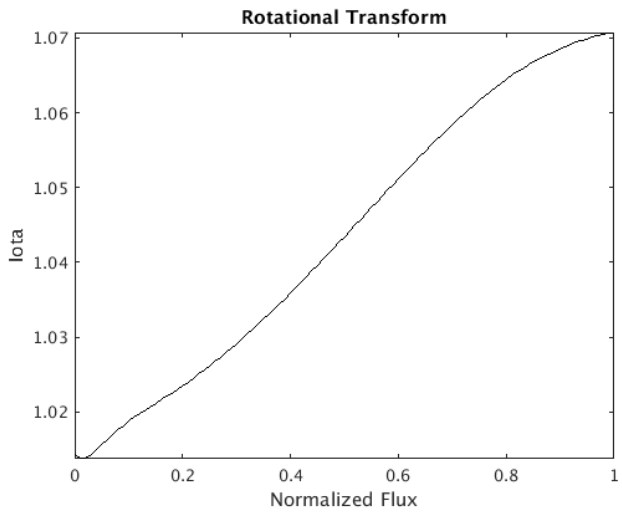

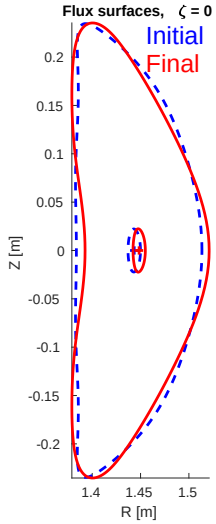

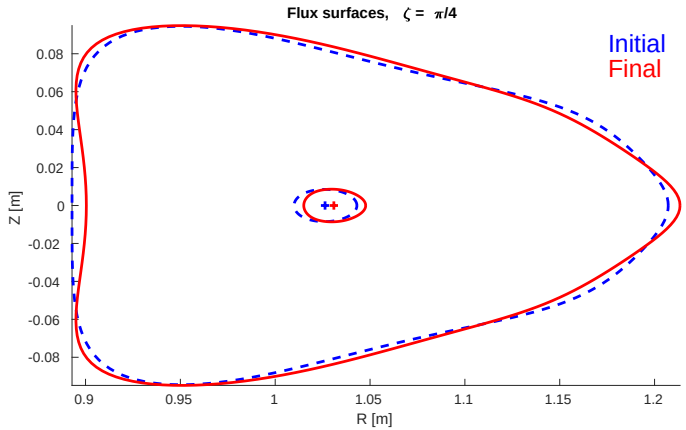

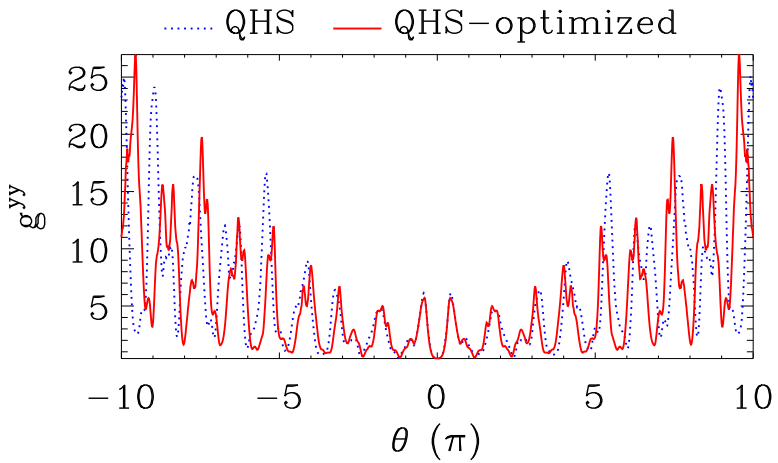

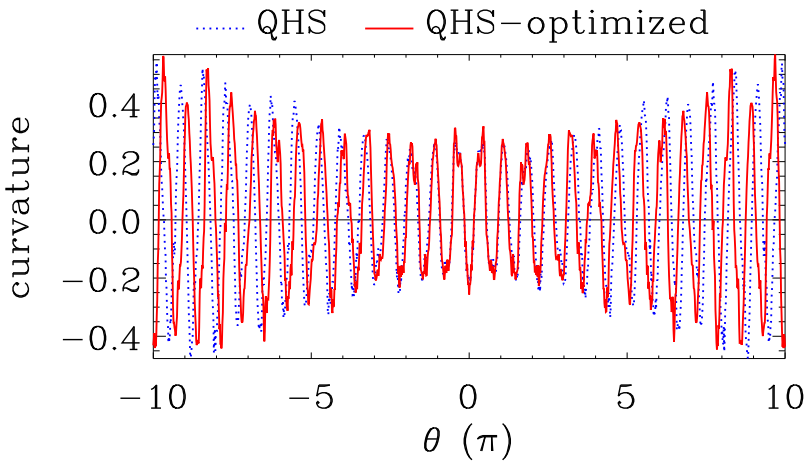

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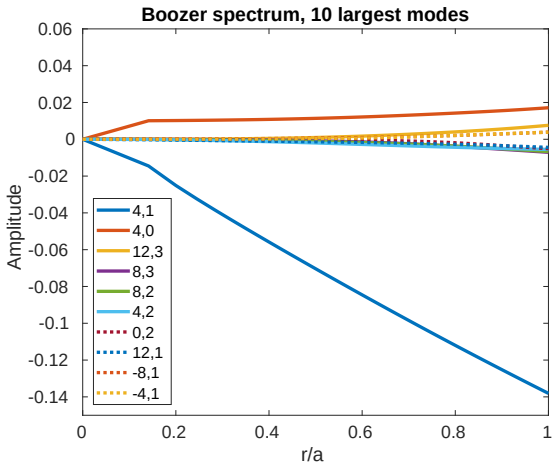

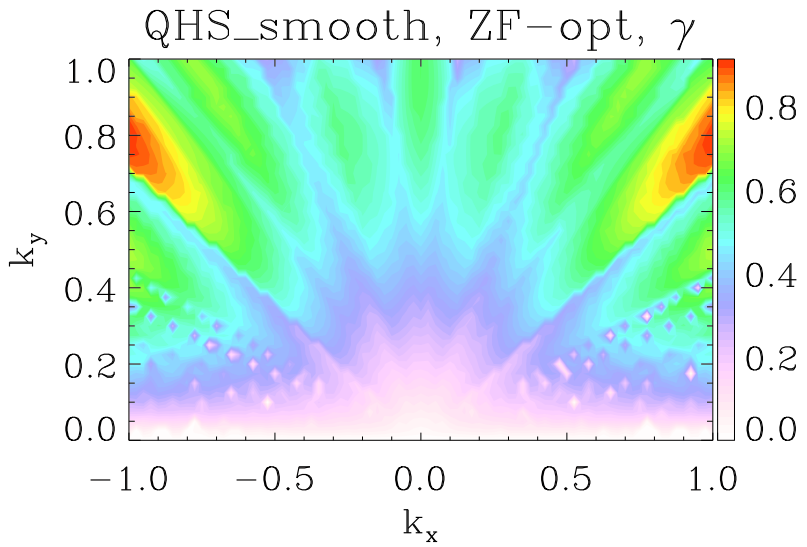

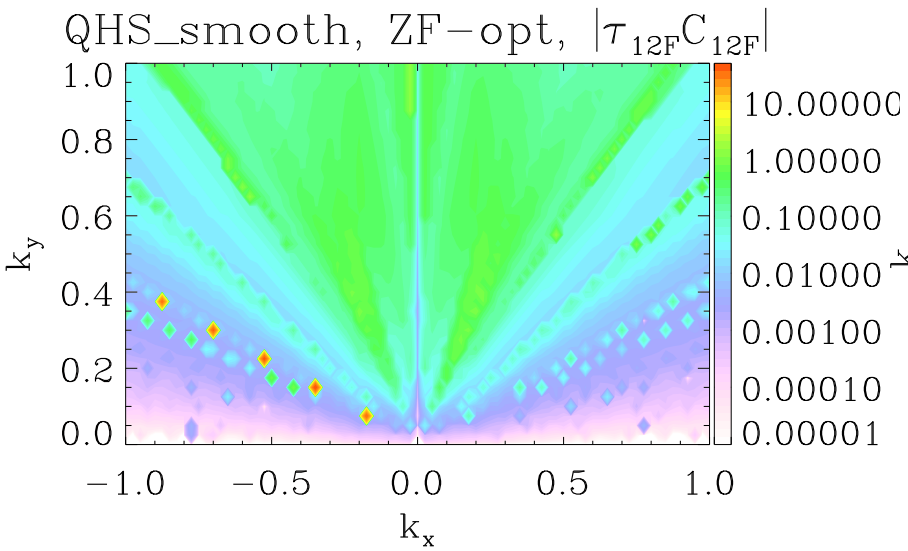

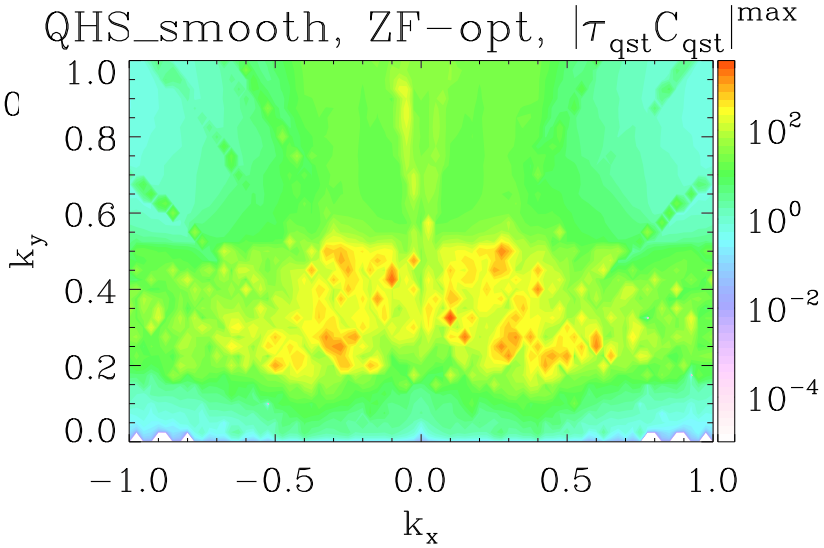

QHS-smooth, Zonal Flow Energy Transfer

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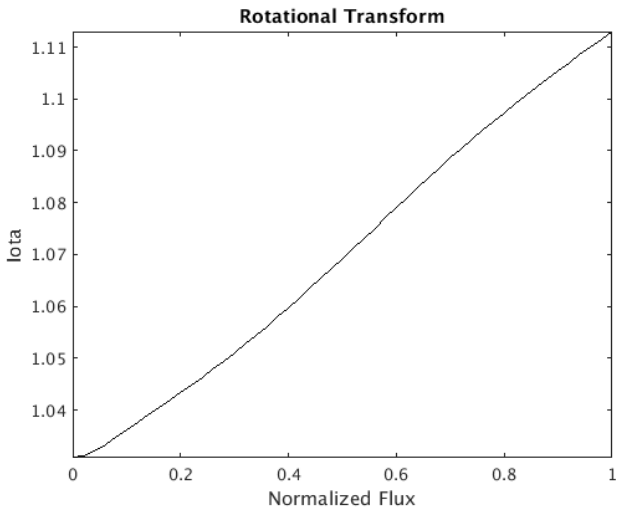

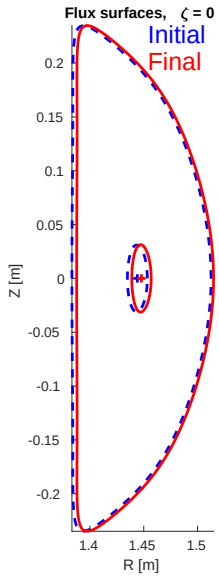

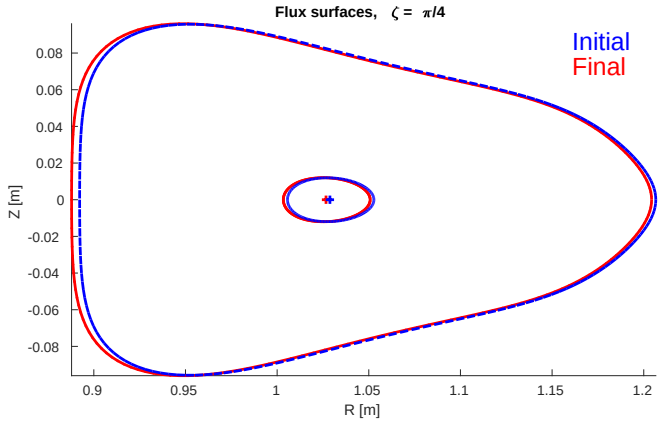

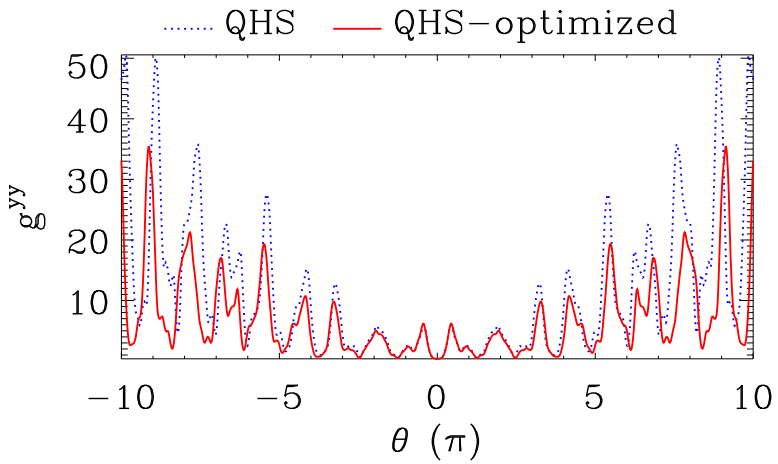

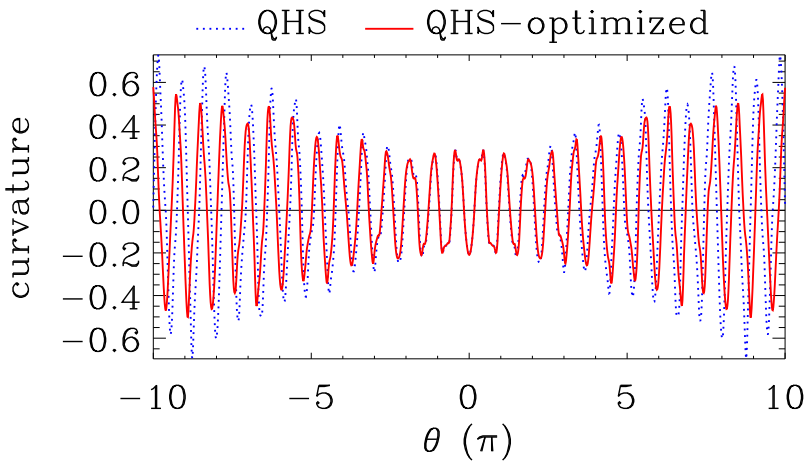

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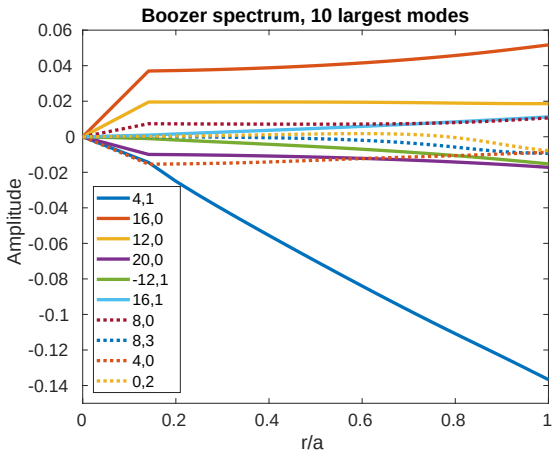

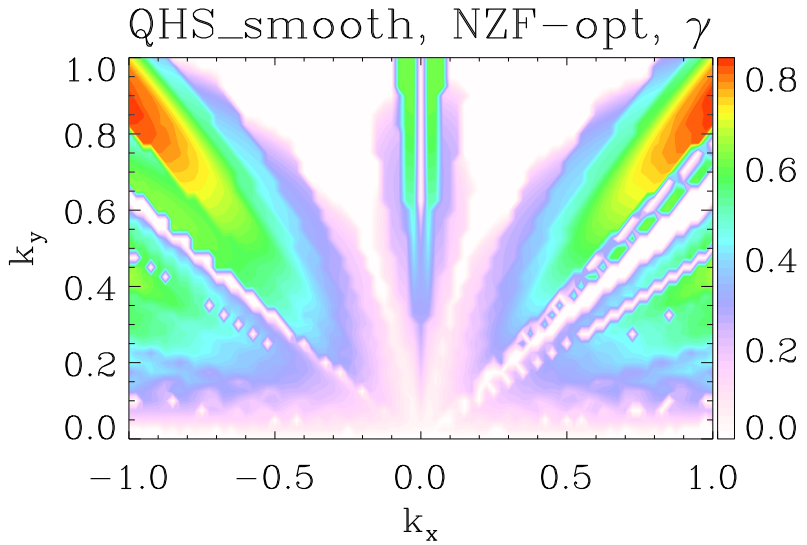

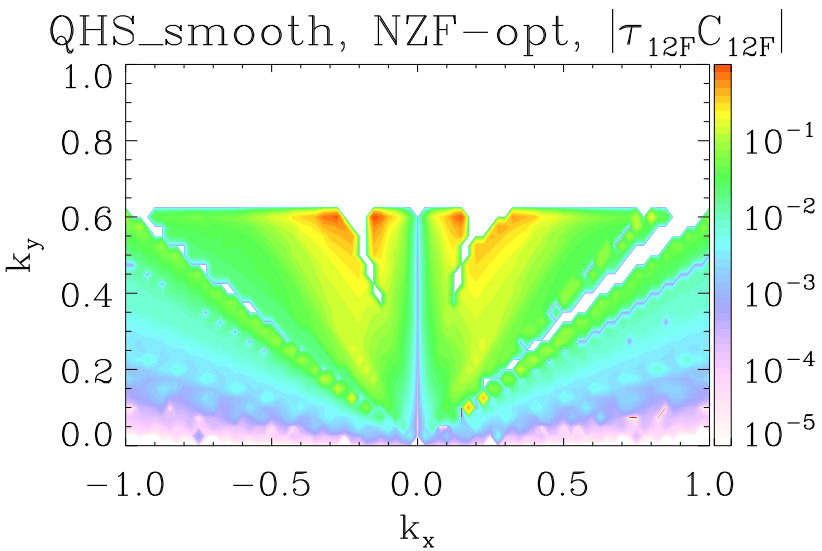

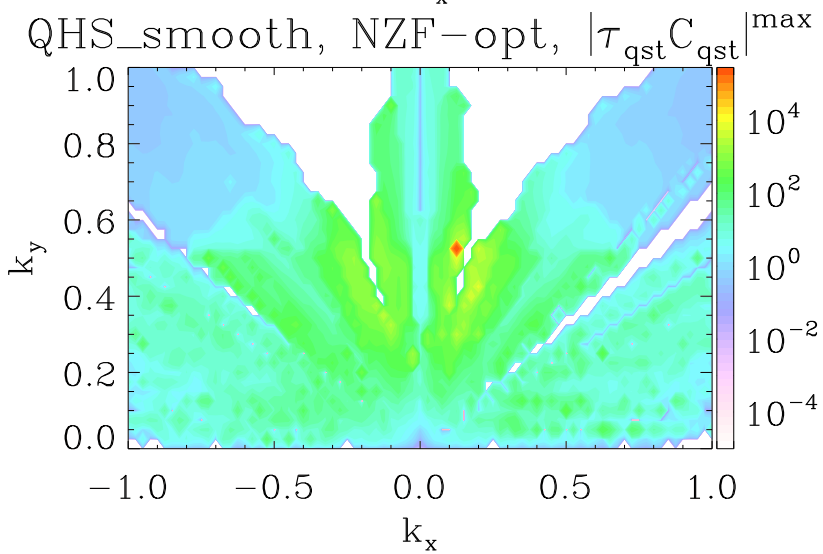

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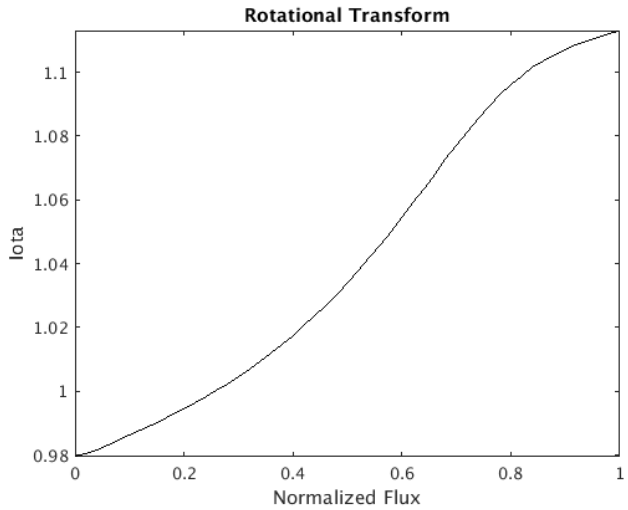

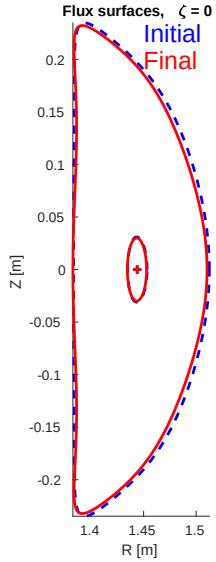

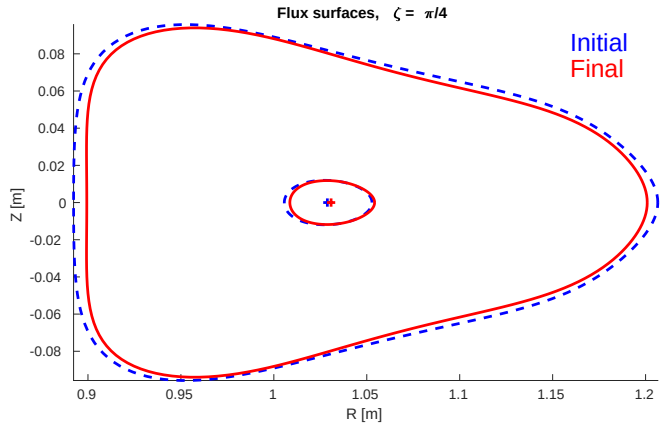

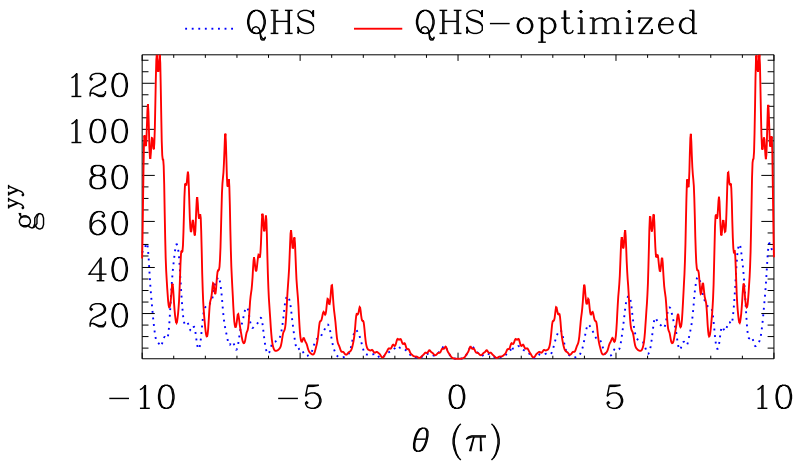

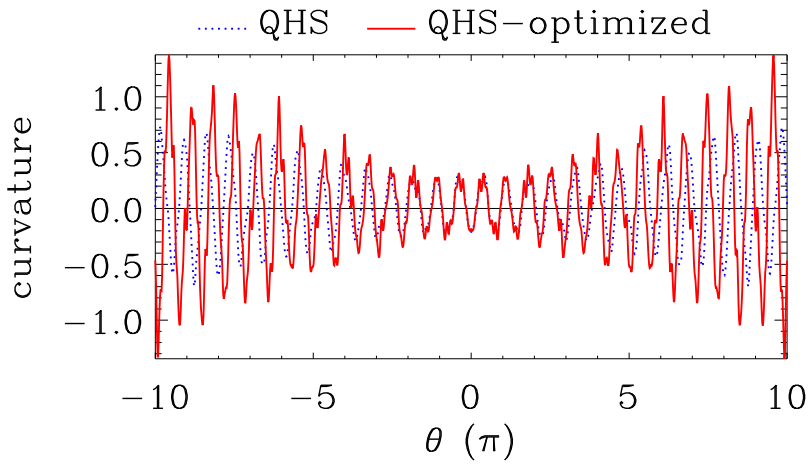

To Do/Open Questions

- GENE simulations of “improved” configurations
- Turbulence model improvements?
  - Model perhaps too sensitive to small geometric changes
  - Add capability to evaluate turbulence metric on multiple surfaces
  - Resolve problem with stellopt_clean_up routines
- Optimization improvements?
  - Is this the correct way to perform optimization? More constraints?
  - Add more targets, like linear growth rate minimization?
- Write my dissertation