Initial Stellopt Runs

A. Bader, J. Schmitt

Wistell Meeting, Mar 3, 2018

Outline

- Gaining intuition about stellarator configurations
- Finding a common language for interpreting Stellopt (or any optimizer code) results
- Current tools we have
- Results of some initial optimization runs

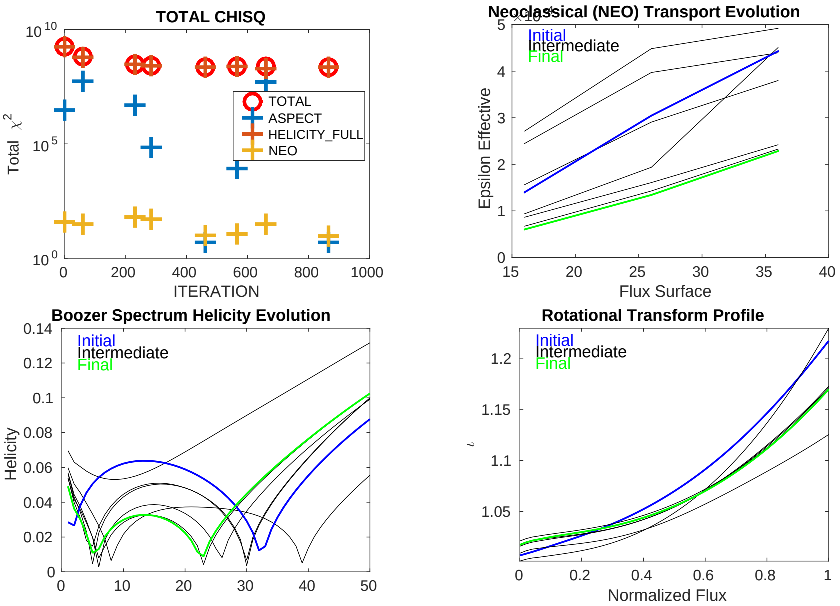
Stellopt 101

- Stellopt is a tool designed to optimize magnetic equilibria
- Composed of two parts:
  - Optimizing algorithms: Levenberg-Marquardt is the standard, but other choices are available.
  - Target functions: stand-alone programs that represent the various targets that you need to meet (aspect ratio, neo-classical transport, rotational transform, etc.
- This talk: Only use LM, and explore different combinations of variables

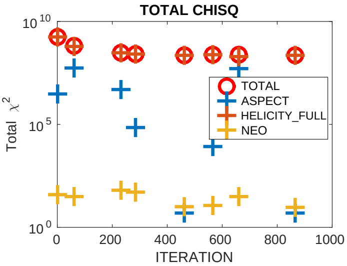
Need to gain intuition about where different constraints push the equilibria

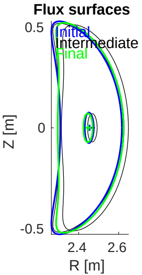
- Favoring different targets pushes the equilibria in different ways
- We need to build understanding of how equilibria react to different forcing
- Targets examined in this talk:
  - Aspect ratio (AR)
  - Helicity (QS): measures the ratio of magnetic energy in undesirable modes, to the energy in the desired mode (in all cases here the -4,1 mode), evaluable at all flux surfaces
  - Neo-classical transport (NEO): Calculated by the NEO code. Evaluates the effective ripple, ϵ_{eff}, evaluable at all flux surfaces
  - ι: Target rotational transform, evaluable at all flux surfaces
  - Regcoil: Given a target separation distance and a maximum current density, evaluate how well a surface current can match the plasma field. (not today)

QHS46: Optimization for AR, NEO, QS

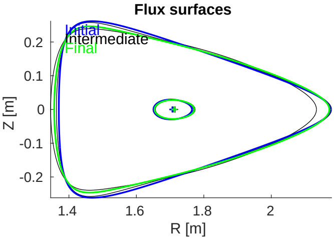


QHS46: Optimization for AR, NEO, QS

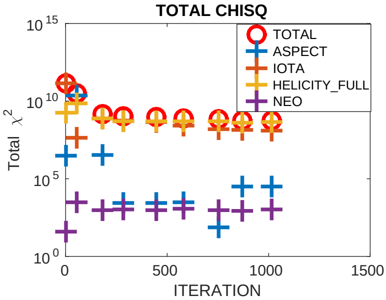


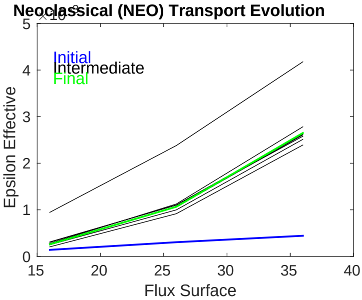


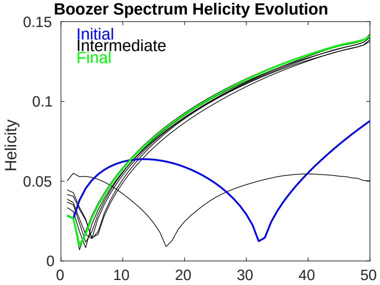
- Quasi-symmetry is the most difficult to optimize for
- Aspect ratio is also important
- Neo mostly irrelevant for this run

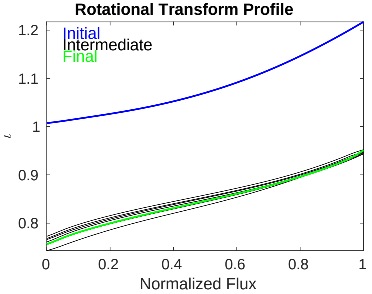


QHS46: Optimization for AR, NEO, QS, ι

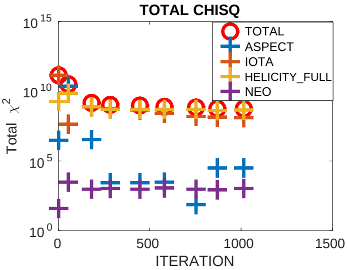




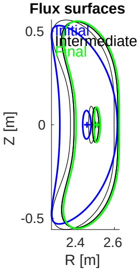


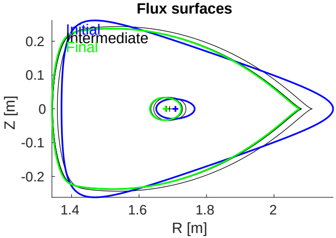


QHS46: Optimization for AR, NEO, QS, ι

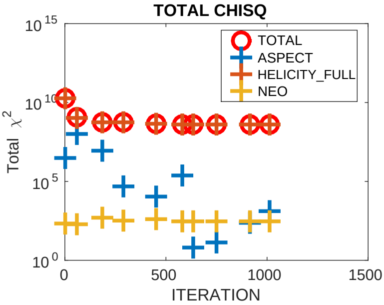


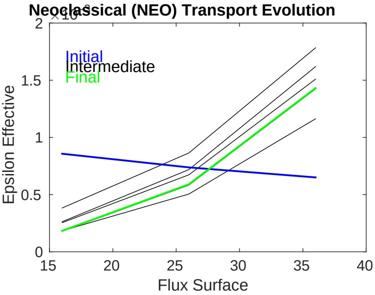
- Forcing ι profile comes at the expense of QS and Neo
- Forcing constraint on AR, causes higher eccentricity
- HEL and ι appear to directly compete with each other

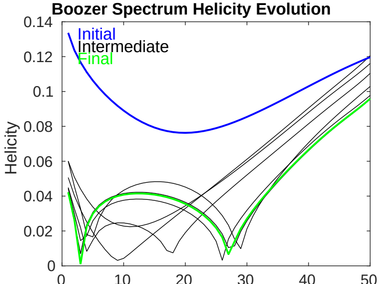


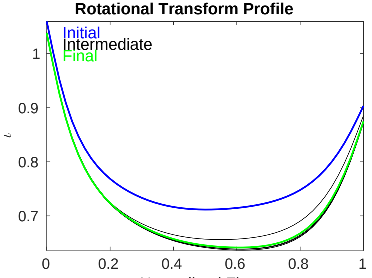


QHS46: Optimization for AR, NEO, QS, with plasma current

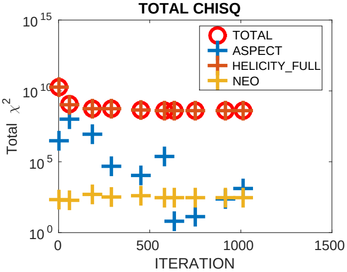


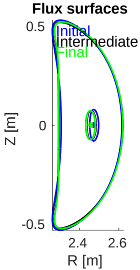




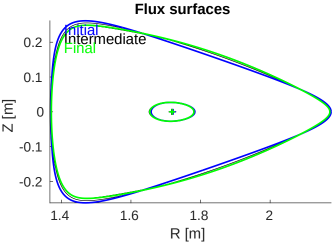


QHS46: Optimization for AR, NEO, QS with plasma current

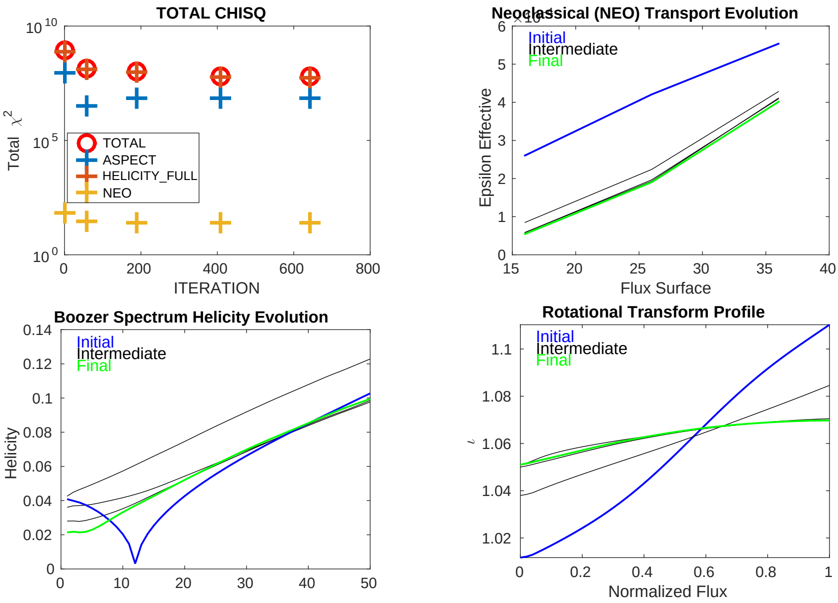




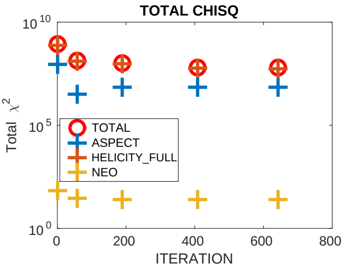
- Realistic current profile provided using Sfincs (by JCS)
- Can improve QS, with minimal flux surface modification



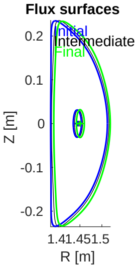
HSX: Optimization for AR, NEO, QS

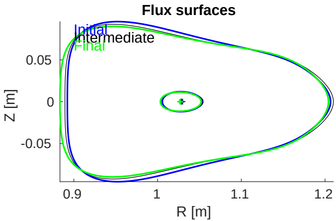


HSX: Optimization for AR, NEO, QS

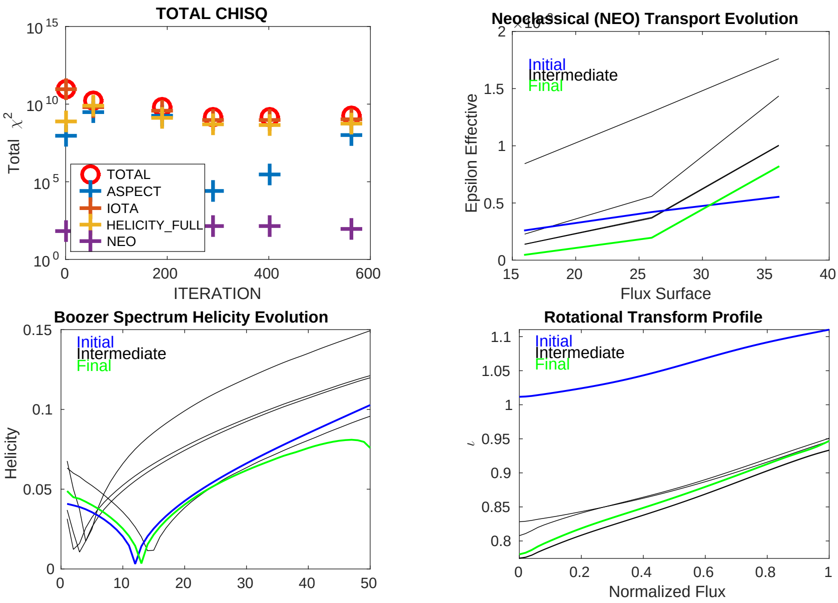


- NEO improves
- QS is not generall improved
- Unconstrained ι gets flatter
- Flux surfaces have minimal change

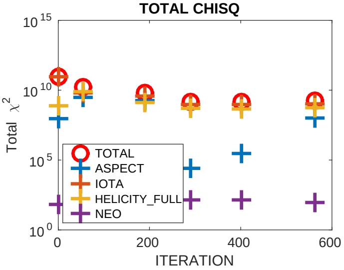


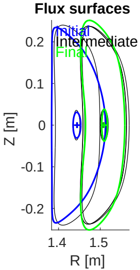


HSX: Optimization for AR, NEO, QS, ι

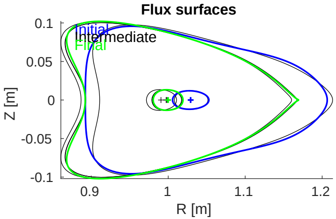


HSX: Optimization for AR, NEO, QS, ι





- At higher AR, ι can be modified with very minimal change in QS and NEO
- As in QHS46, forcing constraint on AR, causes higher eccentricity



Summary

- Basic Stellopt runs have been carried out
- Reliable starting configurations exist for QHS46, QHS46 with some realistic current, and HSX
  - These input files should be put on wistell site (?)
- Regcoil is implemented, but sometimes segfaults for unknown reasons
- Need to pay close attention to specific weights, and adjust as necessary
- Planned next steps (for Aaron)
  - Get meaningful runs including Regcoil
  - Weight NEO over QS, see where it pushes the plasma
  - Get a Beams3D run for energetic ion confinement
  - Implement curvature metric to minimize concave regions?
  - Cheerlead for Ben to get turbulence metric working

Some Technical details about the runs

- 51 radial surfaces
- MPOL = NTOR = 8
- QS minimized on surfaces 7,14,21,28,35,42
- NEO minimized on surfaces 16,26,36
- Other surfaces are included in LM analysis but weighted so as to not be considered
- Typical runs take about 2 hours on 64 processors for 1000 calls to the chisq evaluator (which provides about 7 minima)