Supplemental Slides for:

Using STELLOPT/REGCOIL and to find a better winding surface for QHS46
and
Part 2: Discrete coils, free-boundary VMEC MHD solutions and Poincaré plots

With some bug fixes to plots and other typos

John C. Schmitt

A. Bader, H. Frerichs, M. Landreman, S. Lazerson, E. Paul

AUBURN UNIVERSITY

UNIVERSITY OF MARYLAND

PPPL

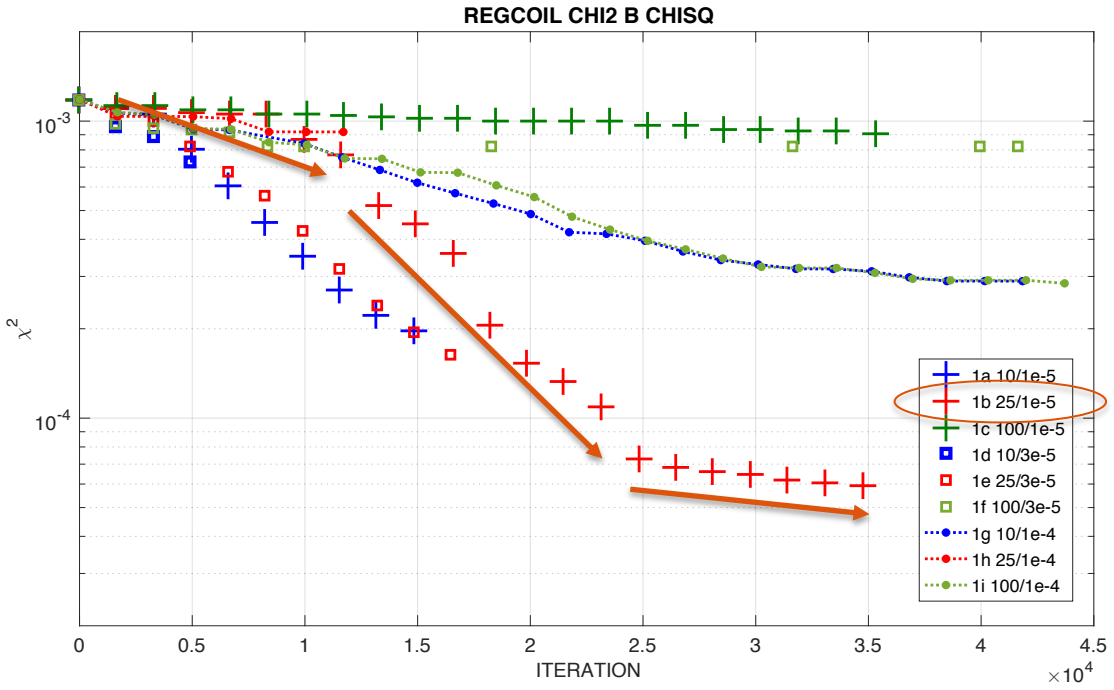
WISCONSIN UNIVERSITY OF WISCONSIN-MADISON

Backup Slides

AUBURN
UNIVERSITY

The next 21 slides show the evolution of the new 'optimal' solution during case 1b with FACTOR/EPSFCN = 25 / 1e-5

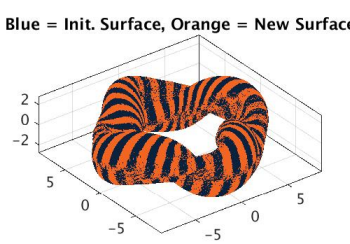
- This is the case shown in red '+' symbols, see arrows
- The first slide will explain what is being shown in each subplot
- There are 21 set of plots, one for each new solution

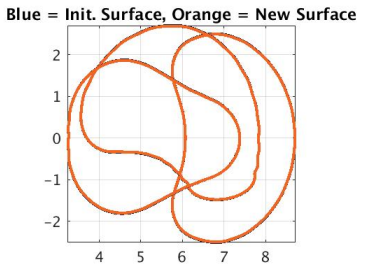


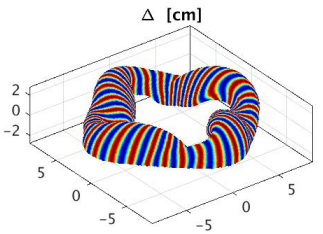
AUBURN UNIVERSITY

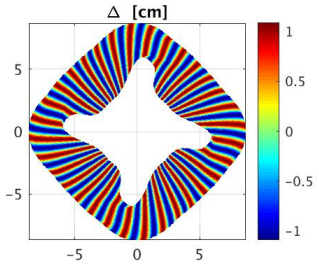
As an example, the first step (but don't dwell on it)

- X, Y, Z axis units are meters
- Upper Left: The original winding surface (in black) and the new winding surface (orange) are superimposed on the same axes. This allows a simple 'binary' eye inspection to see the gross features of the surfaces
- Upper Right: Planar slices of the winding surface at $\zeta = (0°, 45°, 90°) * \frac{360°}{NFP}$
- Lower left and right: The distance (in cm) from the new surface to the original surface, multiplied by the sign of the change in the vertical (Z) –direction

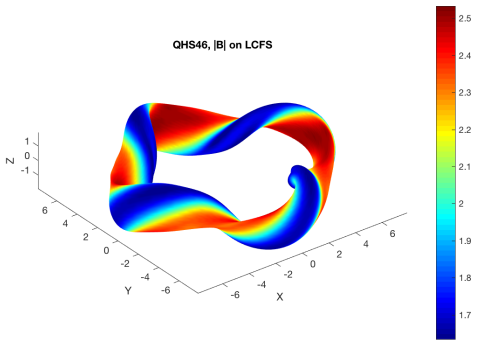






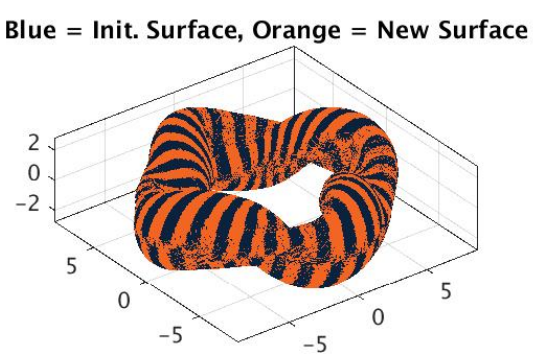


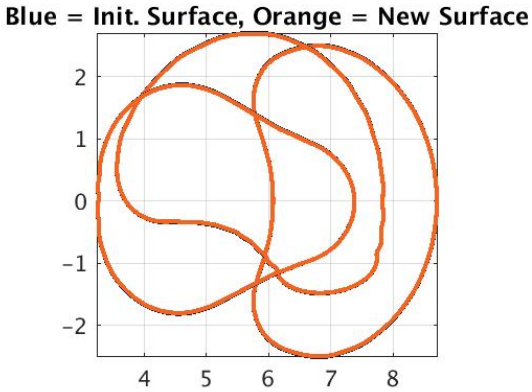
- Original target |B| on target LCFS also shown for reference
  - This is not a 'self-consistent' |B|

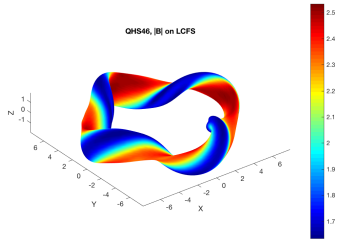


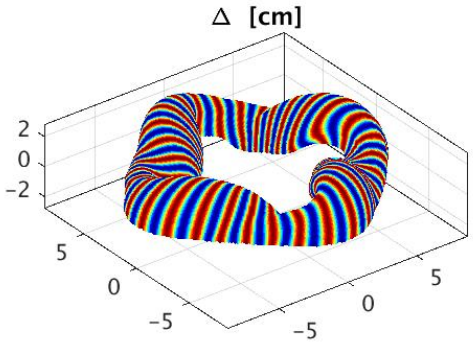
AUBURN UNIVERSITY

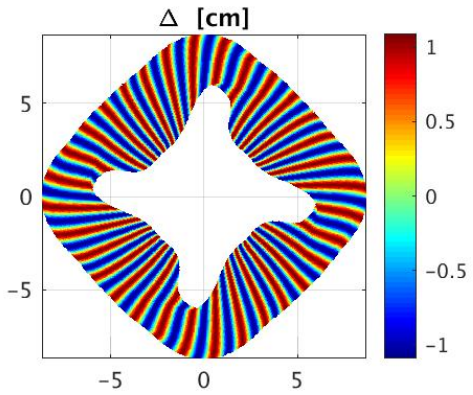
Iterative solution #2, The first step





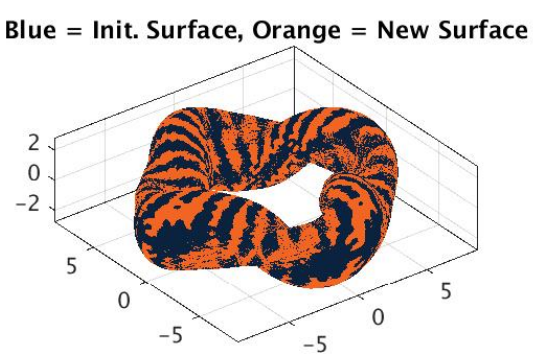


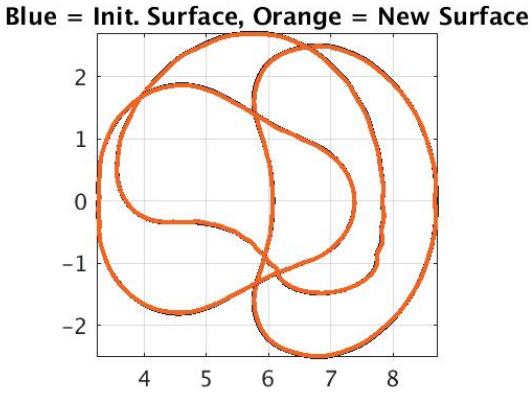


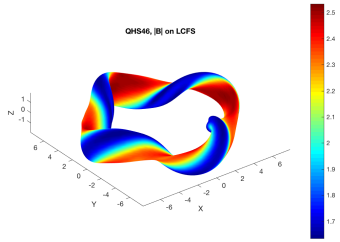


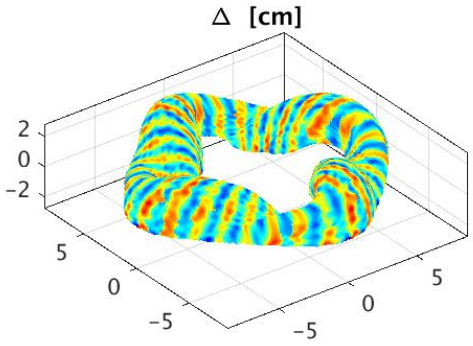
AUBURN UNIVERSITY

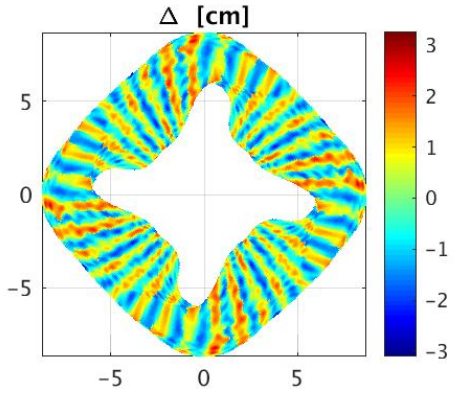
Iterative solution #3





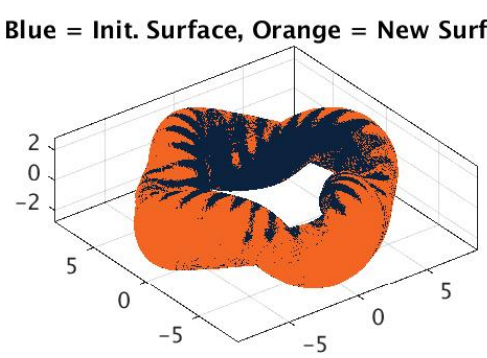


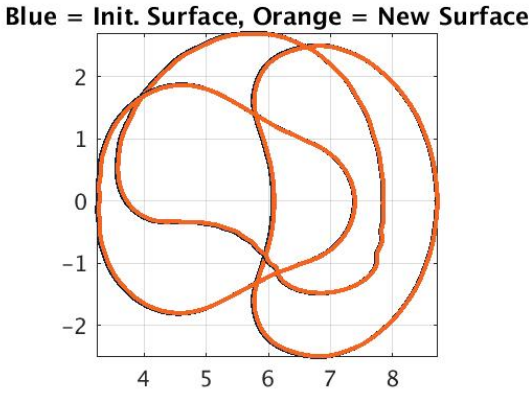


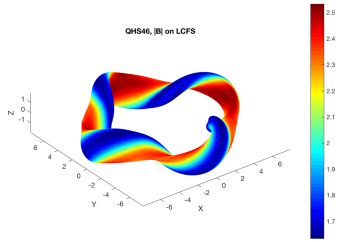


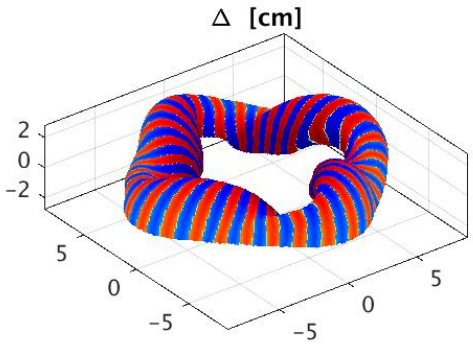
AUBURN UNIVERSITY

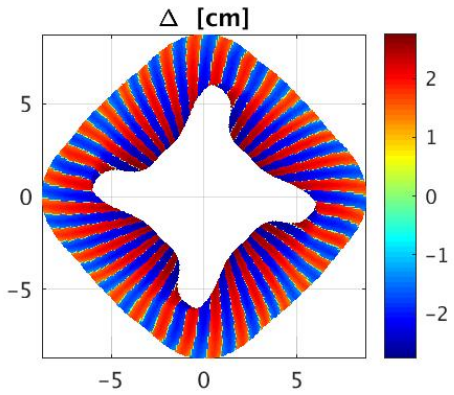
Iterative solution #4





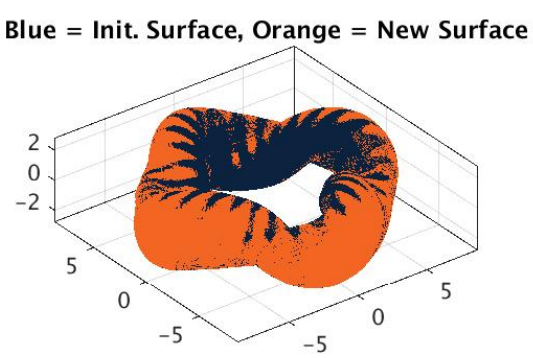


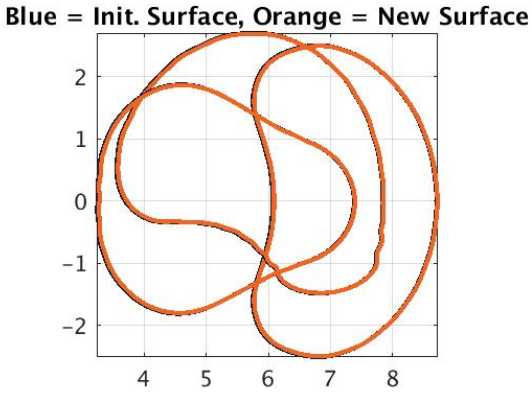


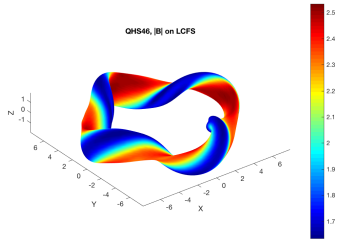


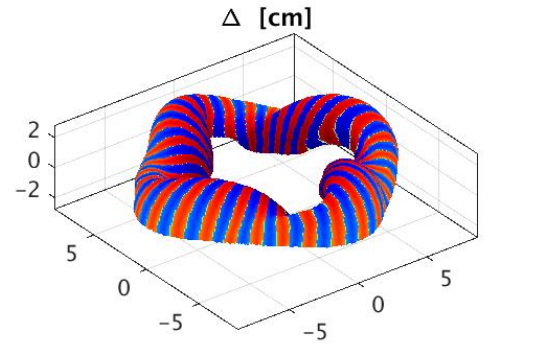
AUBURN UNIVERSITY

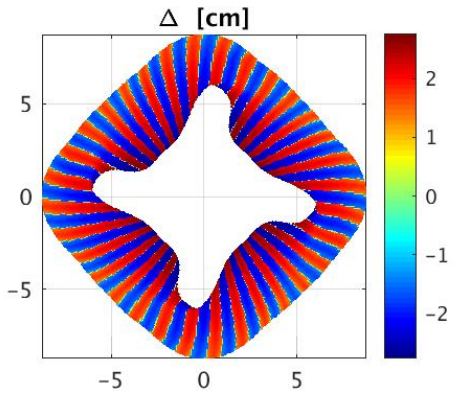
Iterative solution #5





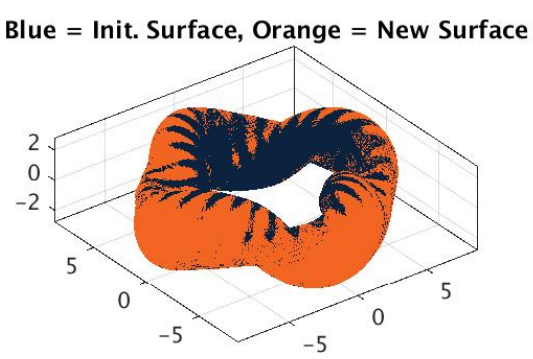


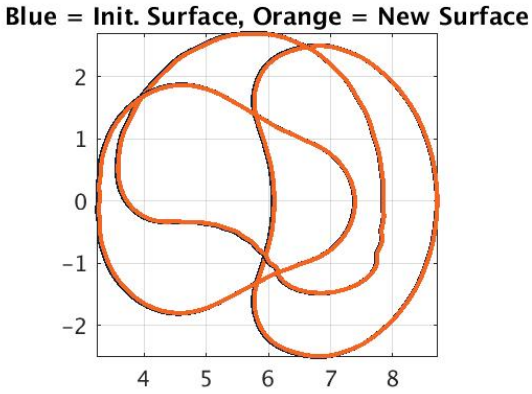


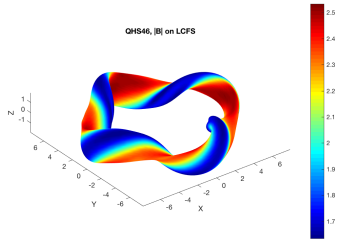


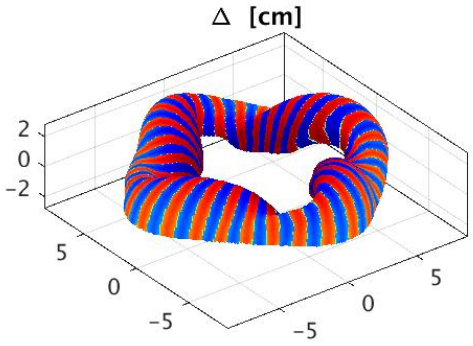
AUBURN UNIVERSITY

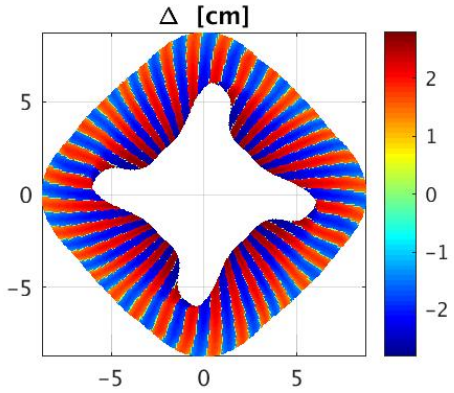
Iterative solution #6





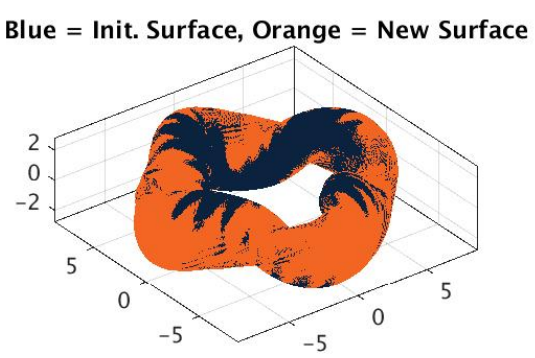


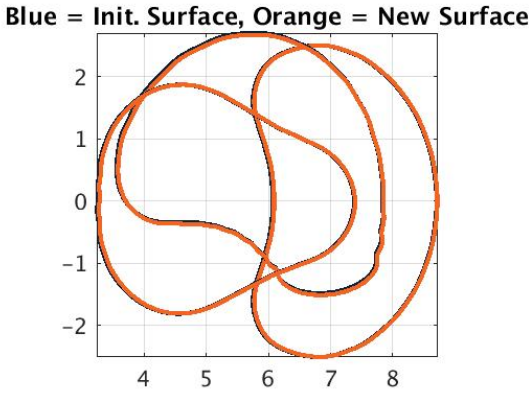


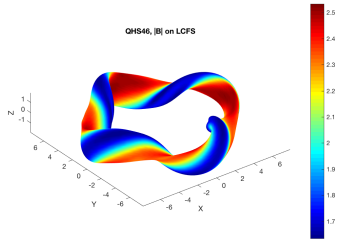


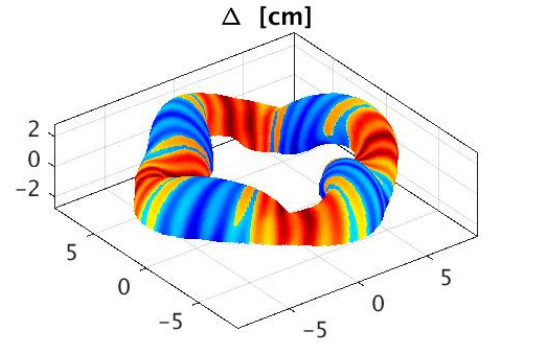
AUBURN UNIVERSITY

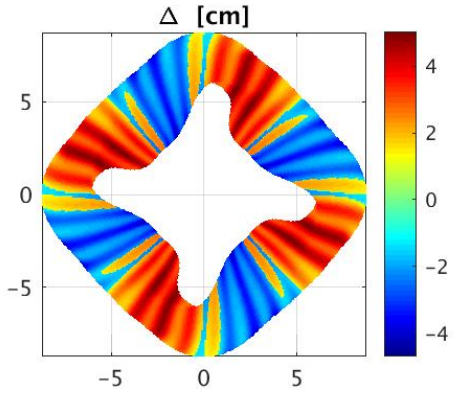
Iterative solution #7





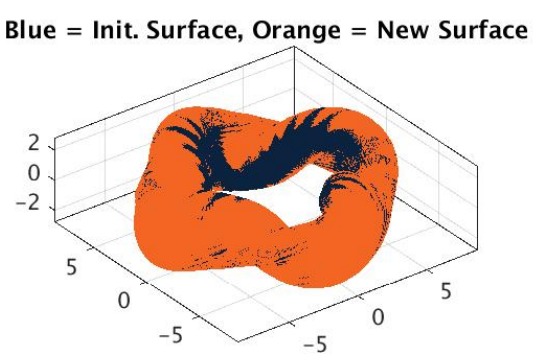


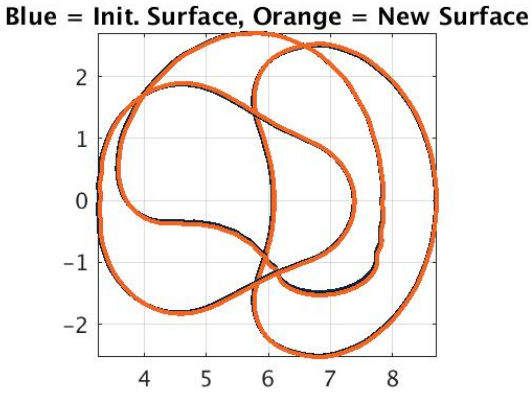


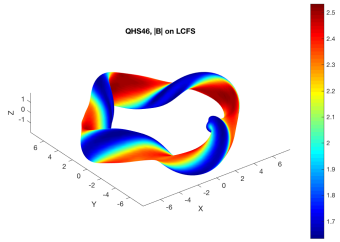


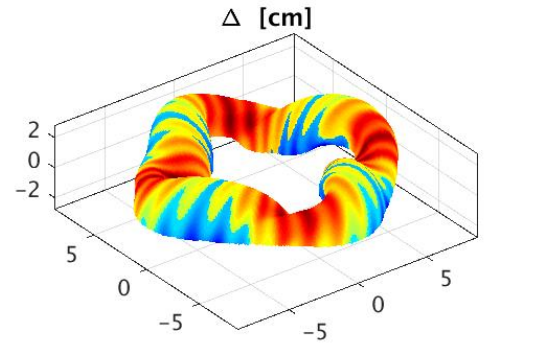
AUBURN UNIVERSITY

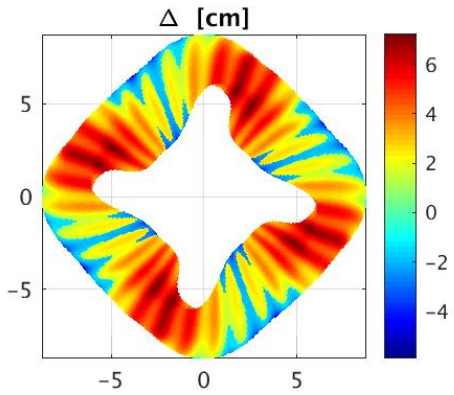
Iterative solution #8





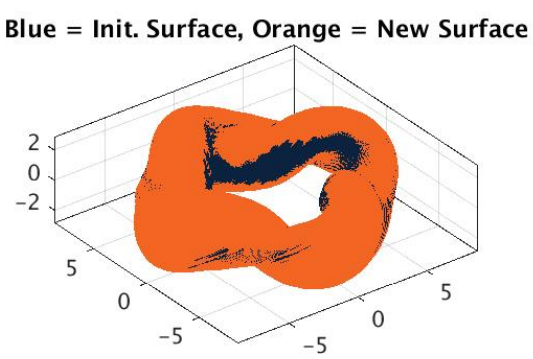


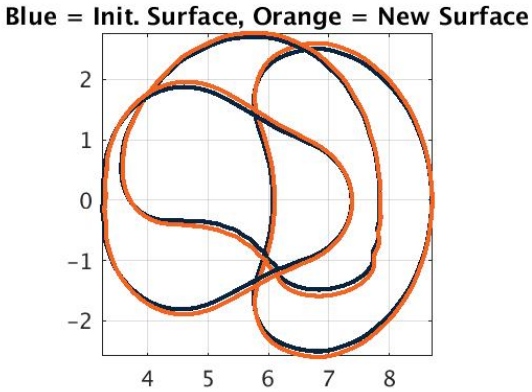


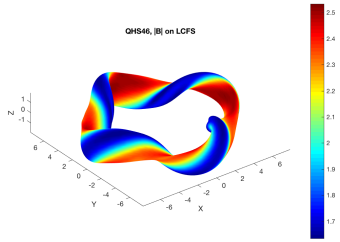


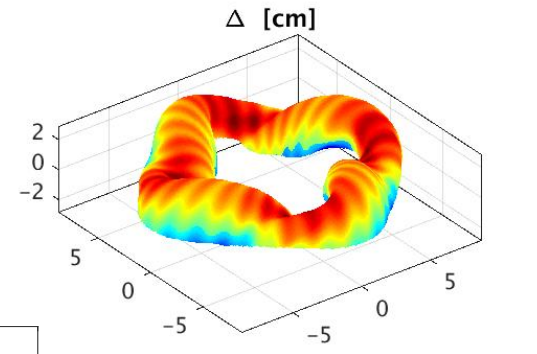
AUBURN UNIVERSITY

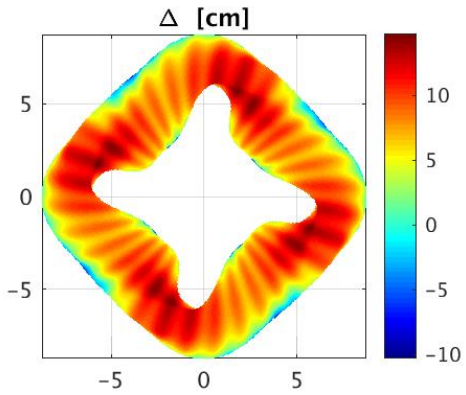
Iterative solution #9: A new rate of descent begins now; Surface will become narrower and taller.

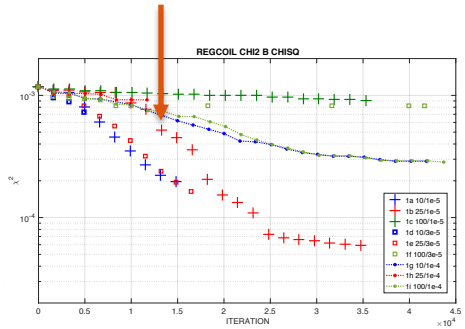




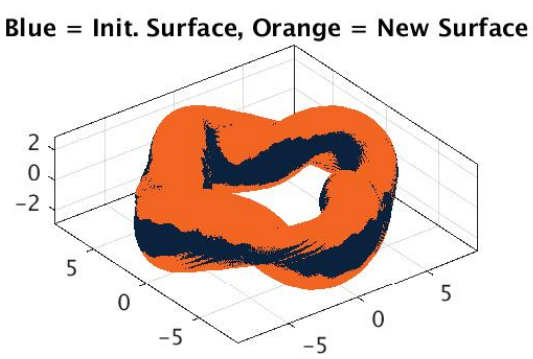


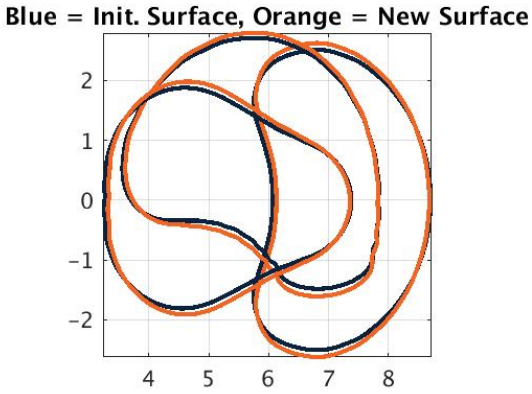


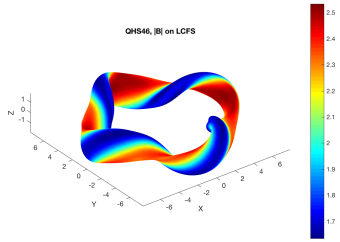


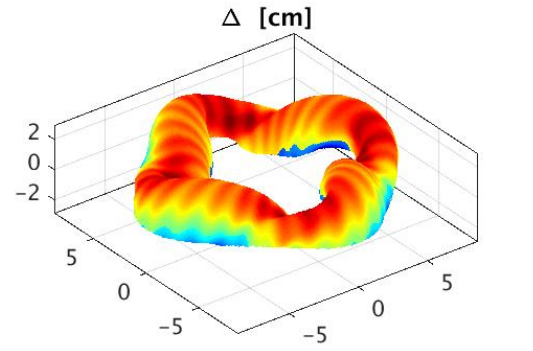


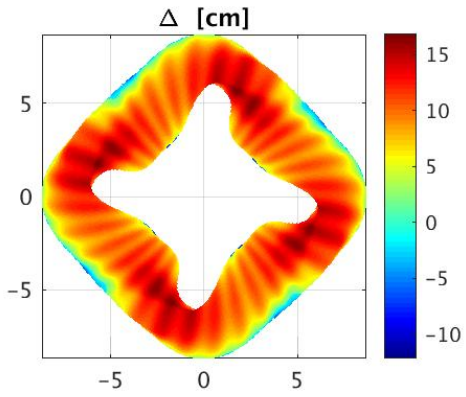
Iterative solution #10





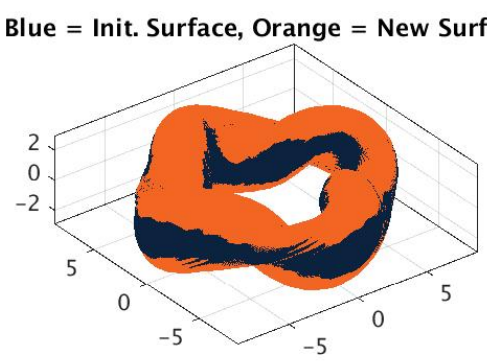


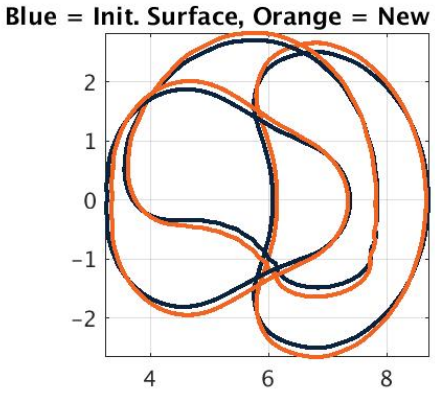


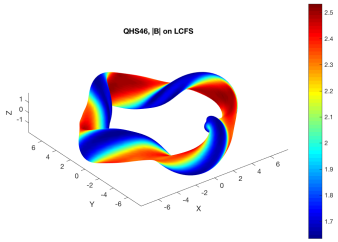


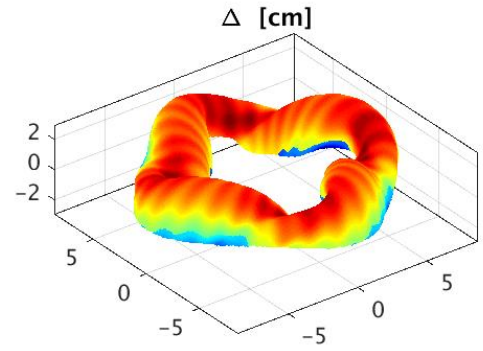
AUBURN UNIVERSITY

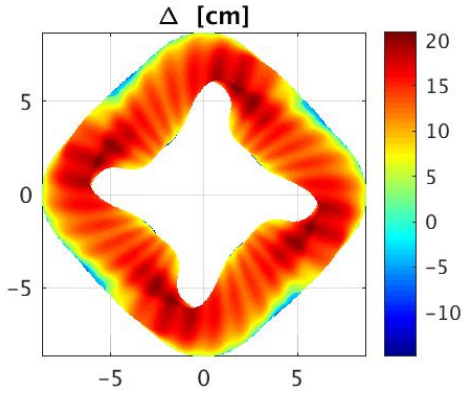
Iterative solution #11





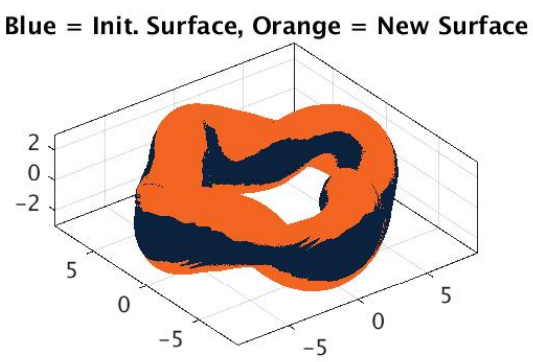


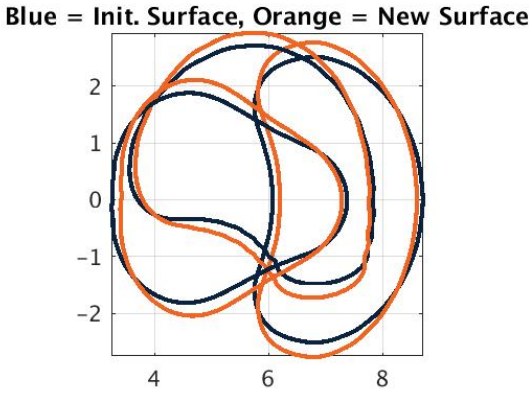


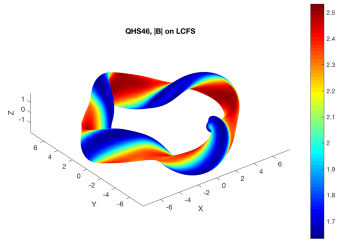


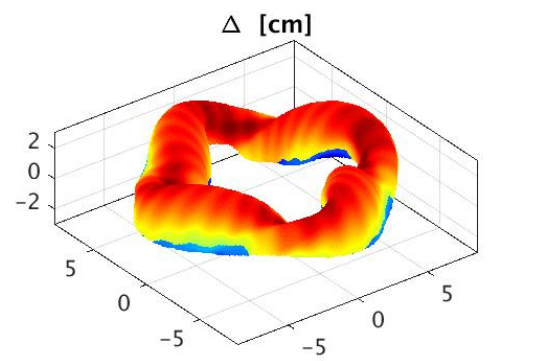
AUBURN UNIVERSITY

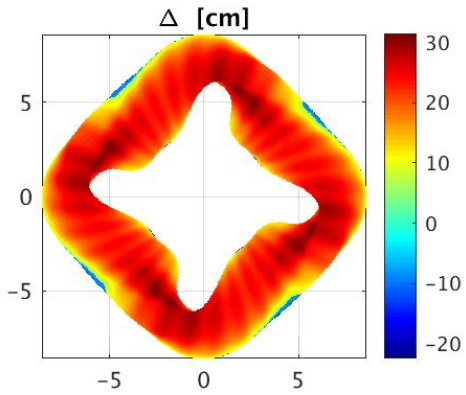
Iterative solution #12





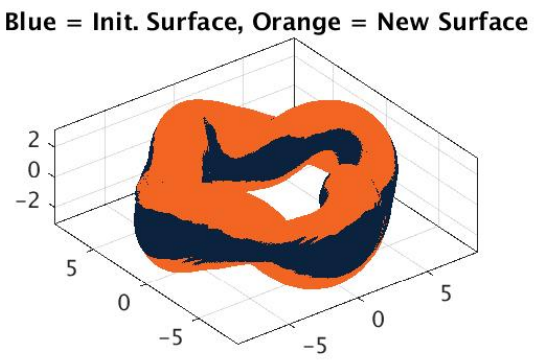


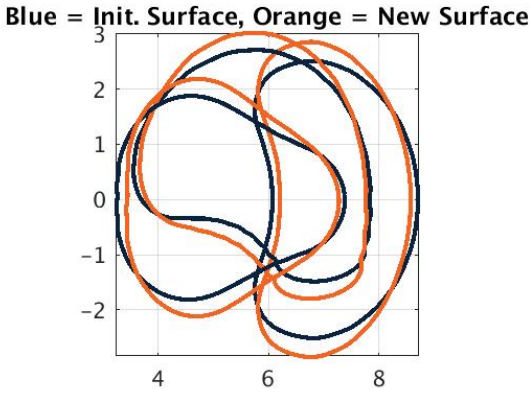


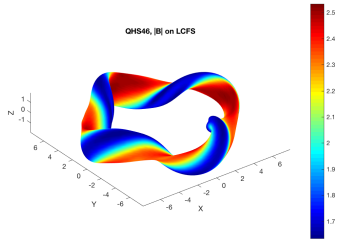


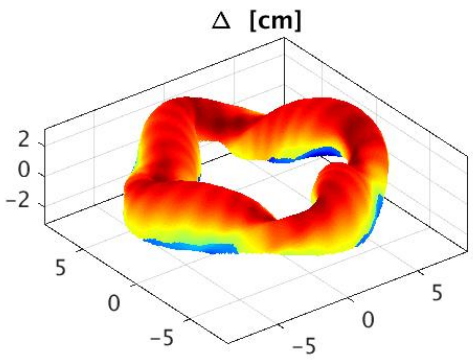
AUBURN UNIVERSITY

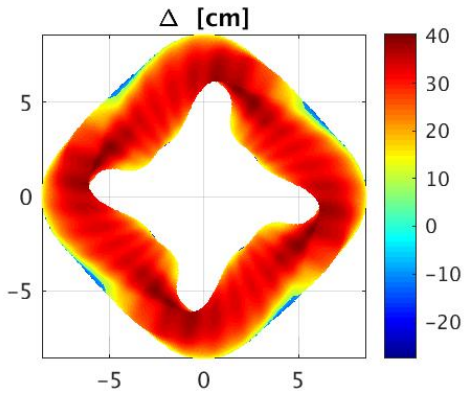
Iterative solution #13





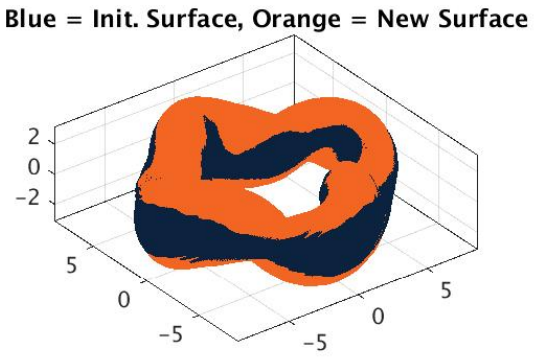


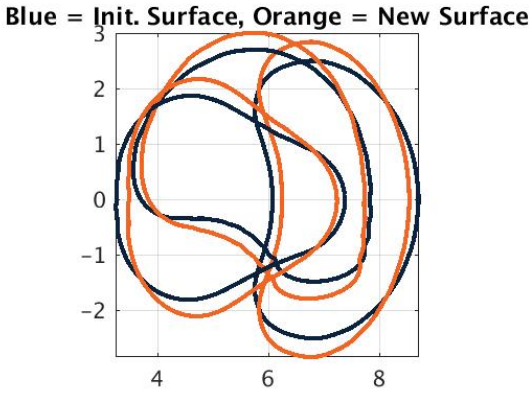


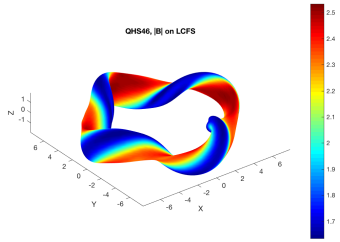


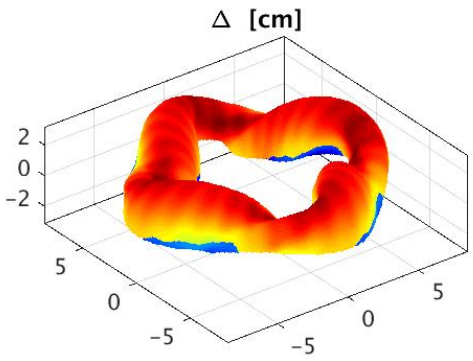
AUBURN UNIVERSITY

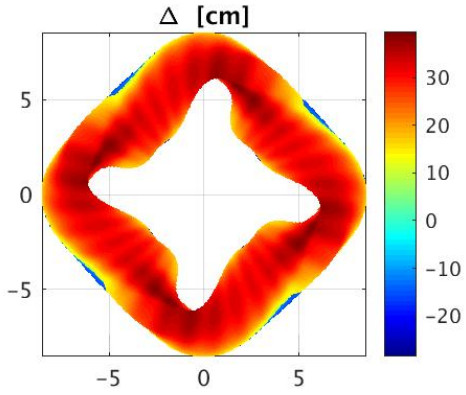
Iterative solution #14





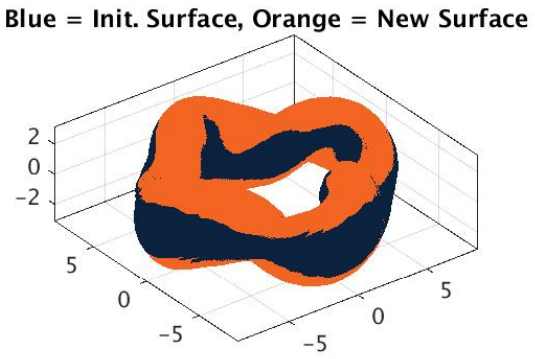


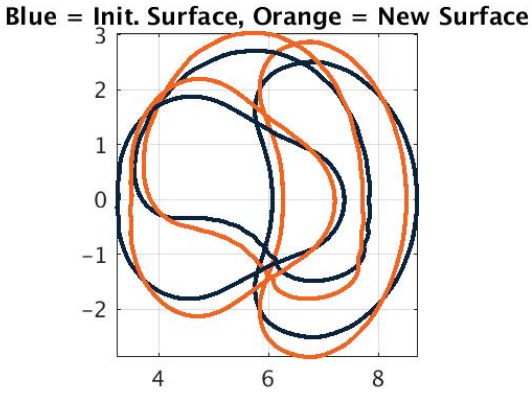


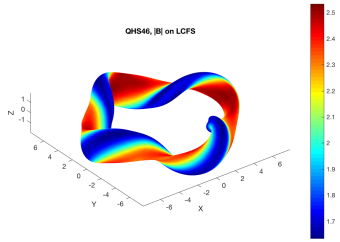


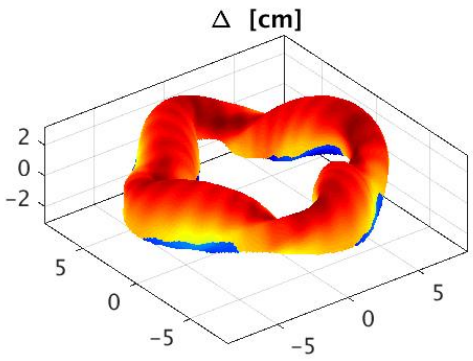
AUBURN UNIVERSITY

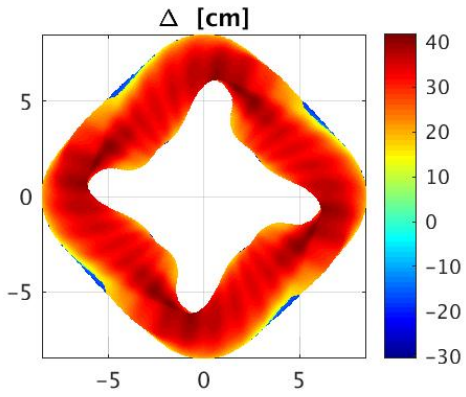
Iterative solution # 15





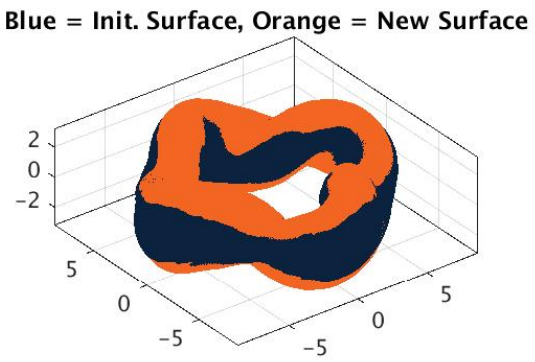


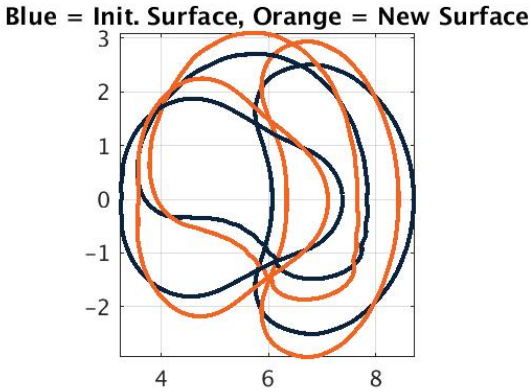


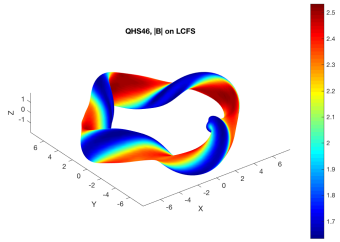


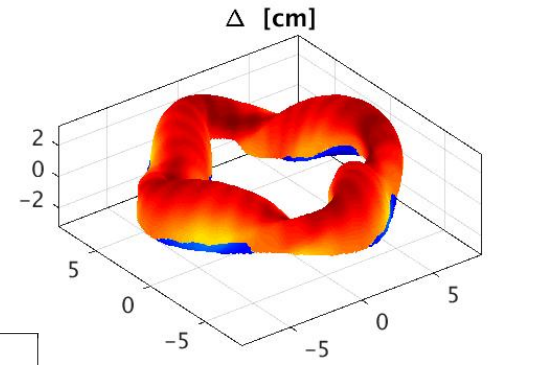
AUBURN UNIVERSITY

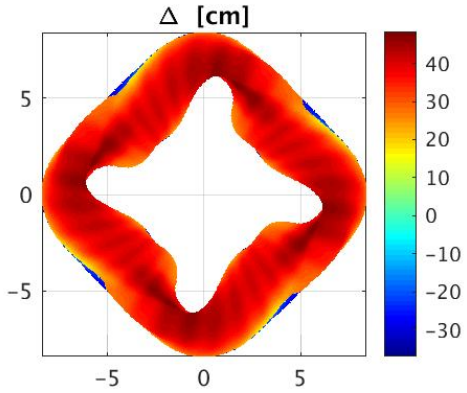
Iterative solution # 16: Descent slows down from here on to the end

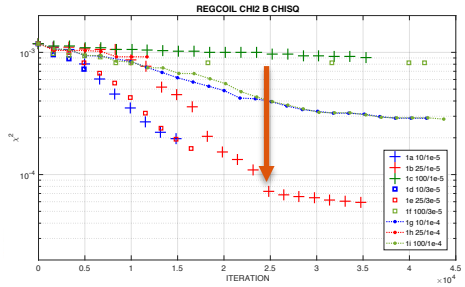




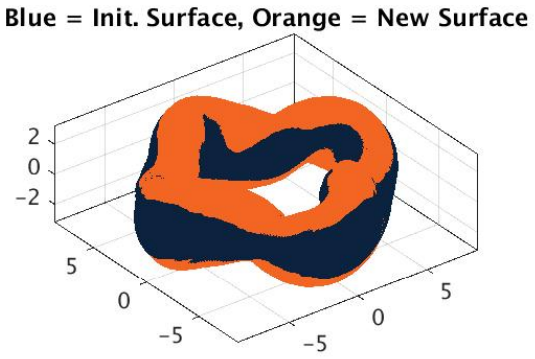


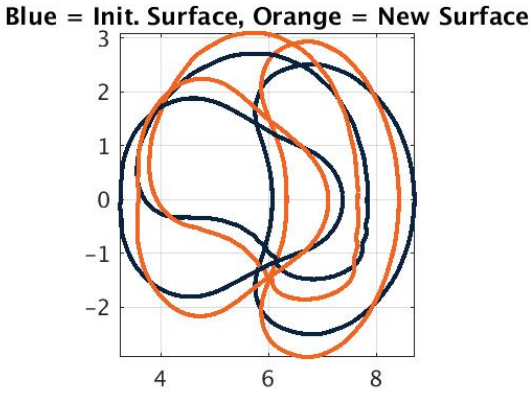


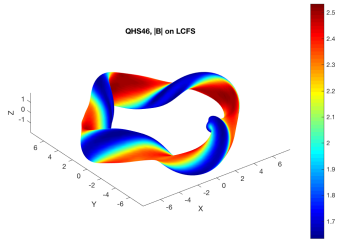


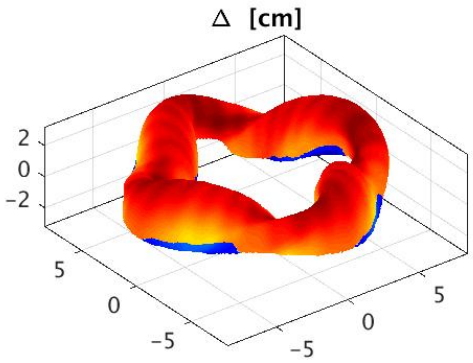


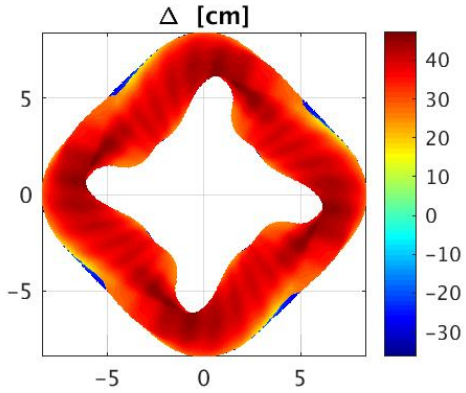
Iterative solution #17





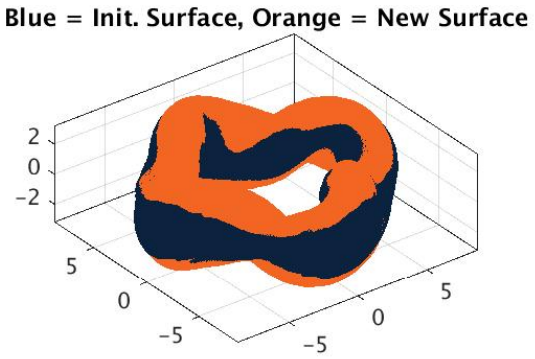


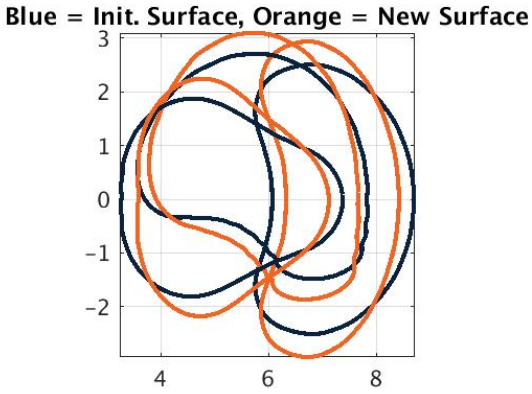


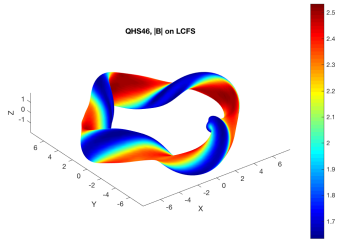


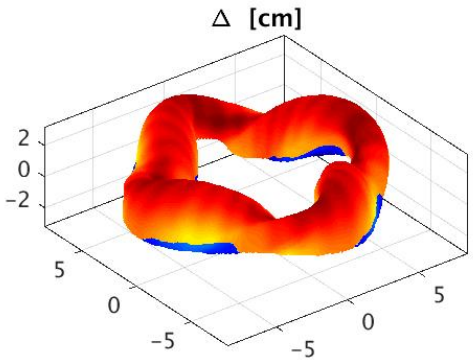
AUBURN UNIVERSITY

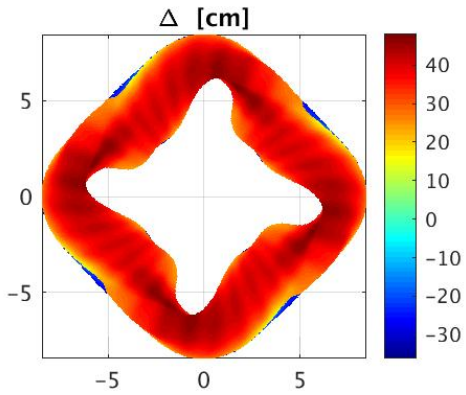
Iterative solution #18





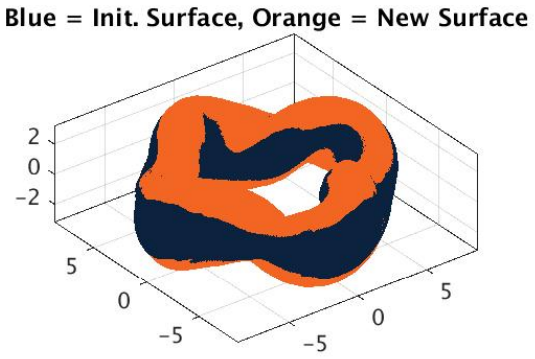


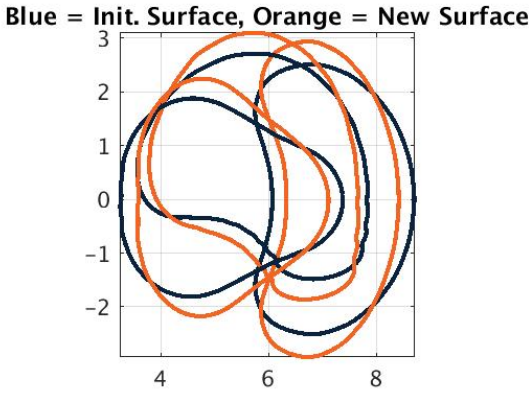


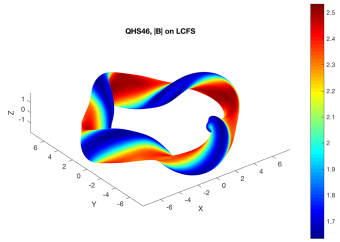


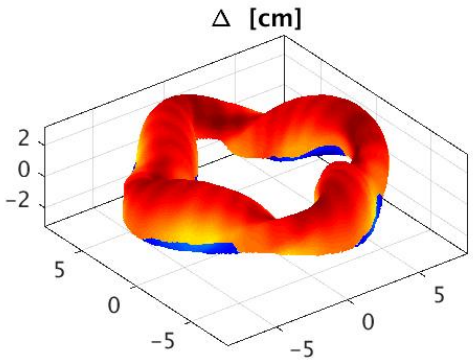
AUBURN UNIVERSITY

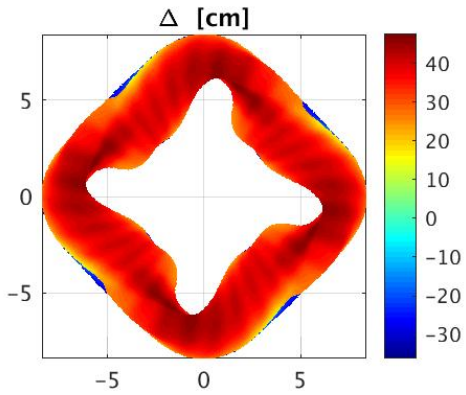
Iterative solution #19





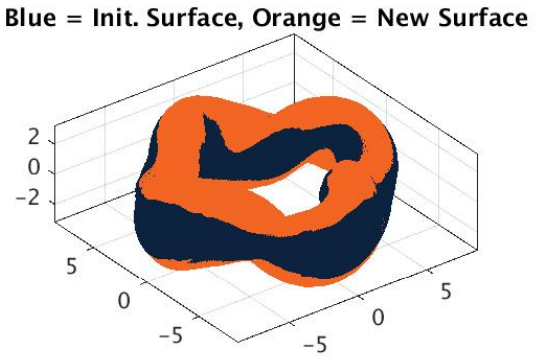


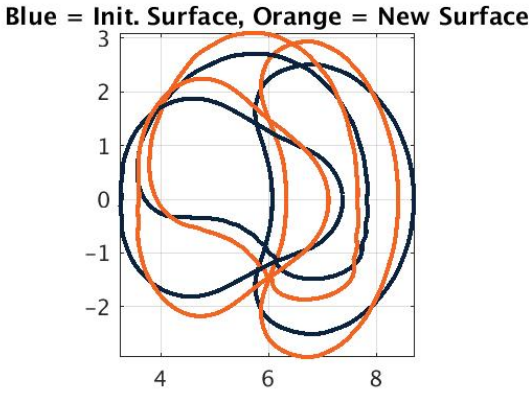


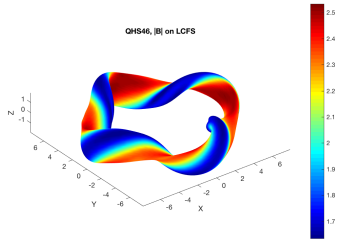


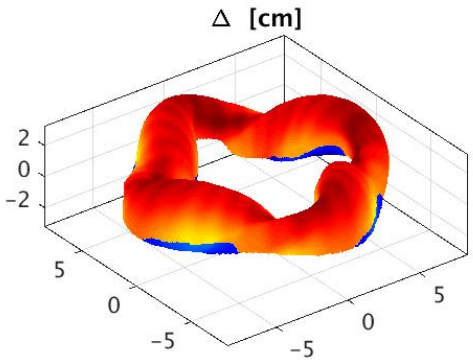
AUBURN UNIVERSITY

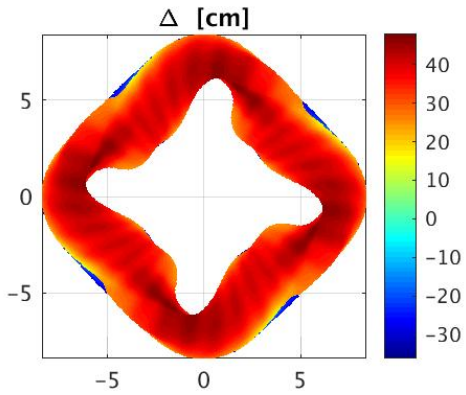
Iterative solution #20





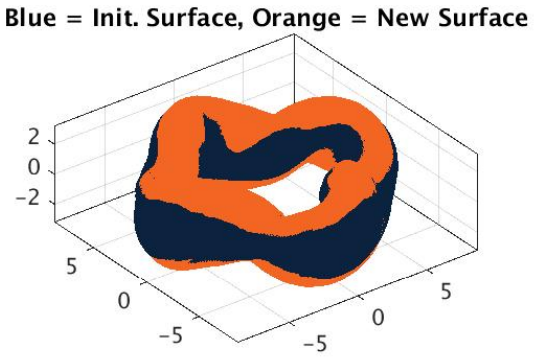


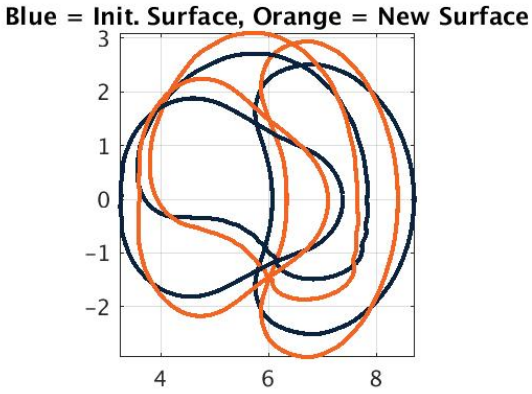


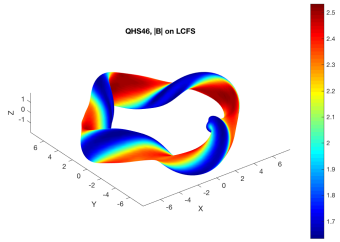


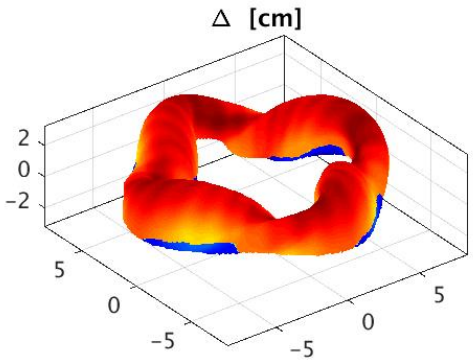
AUBURN UNIVERSITY

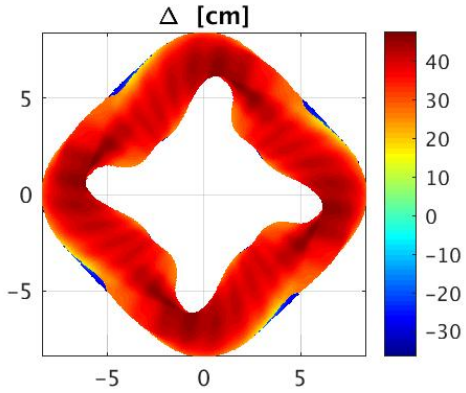
Iterative solution #21







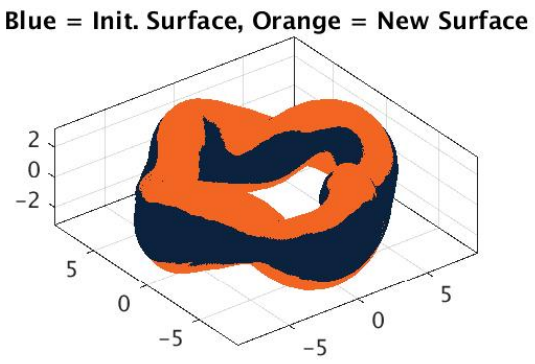


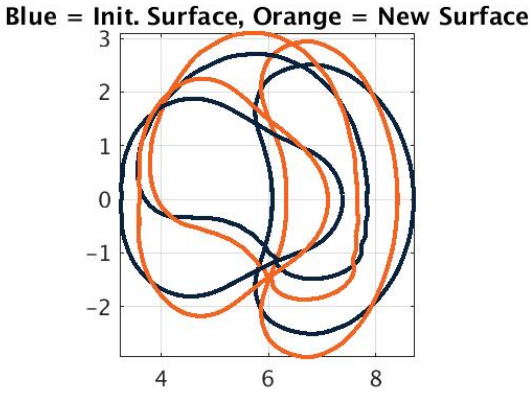


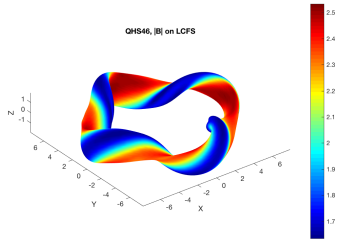
AUBURN UNIVERSITY

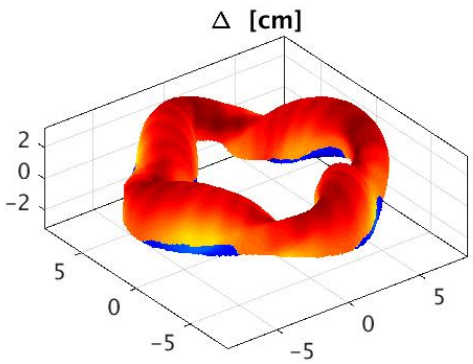
Iterative solution #22: (24x32 cpu-hour time limit)

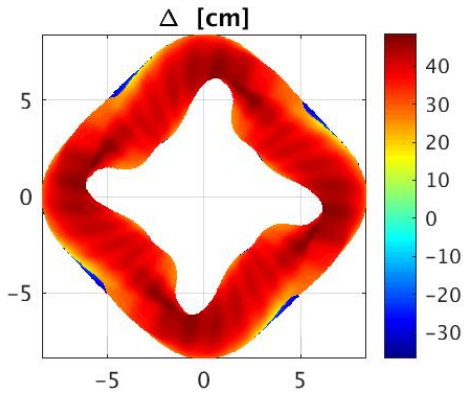
- The solution after the last iteration is teller and narrower than the starting position
- Recall: The starting position was a ‘uniform distance’ away from the plasma boundary











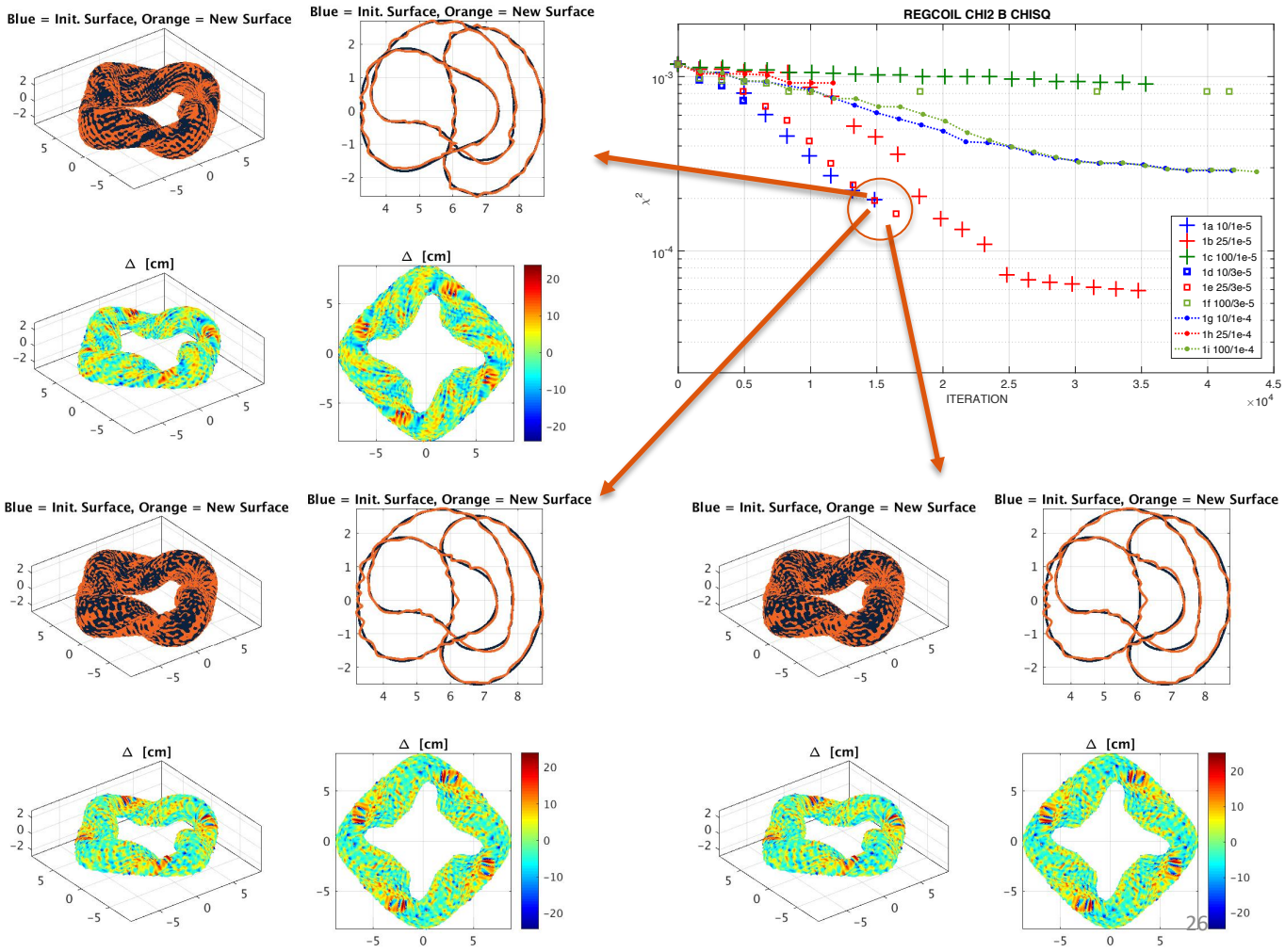
AUBURN UNIVERSITY

The optimizer runs that demonstrated the most rapid descent A) look a little different, B) are still evolving, and C) terminated because the solver was in a local minimum (I think)

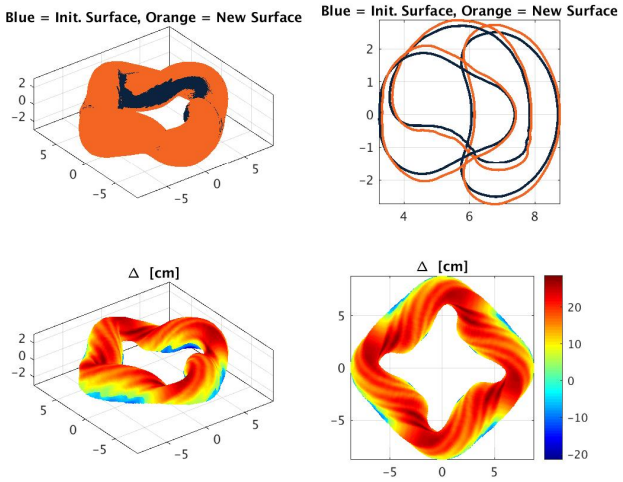
- The surfaces of the two branches that descend more rapidly, but are truncated, look a little different
- blue +'s (upper left)
- red squares (lower left)

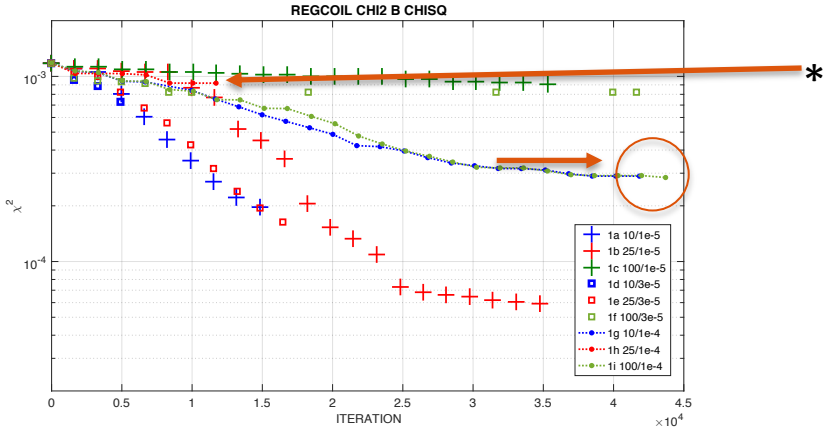
- The red square descent path has one extra step – see lower right plots

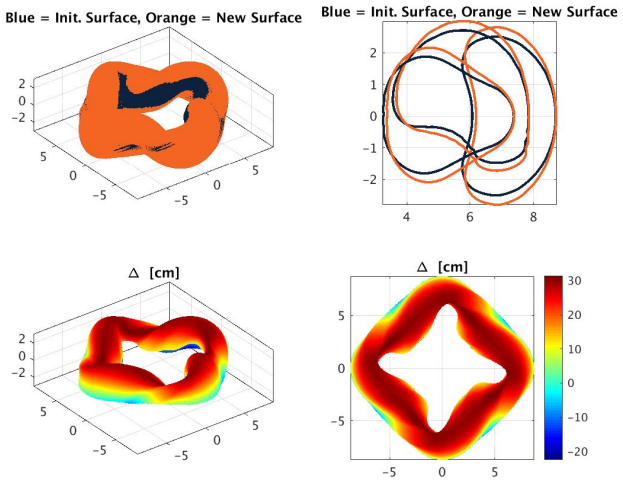
➢ **The solver got stuck in a local minimum?**
  - ➢ "algorithm estimates that the relative error between x and the solution is at most xtol"

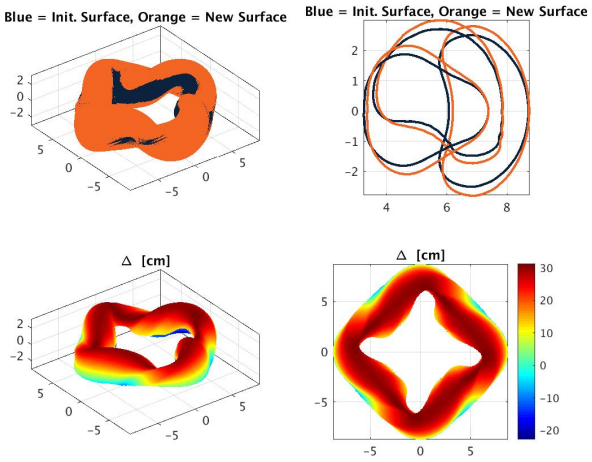


The optimizer branch that descends more slowly looks vaguely like the ‘best’ case: Taller, **but less narrow**!

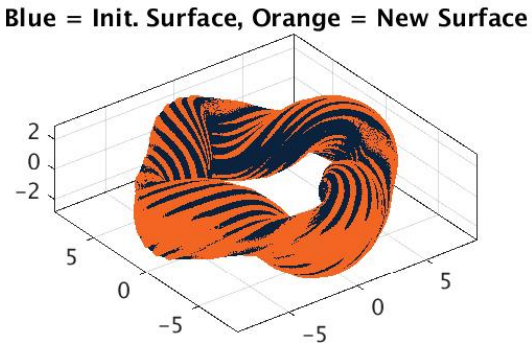


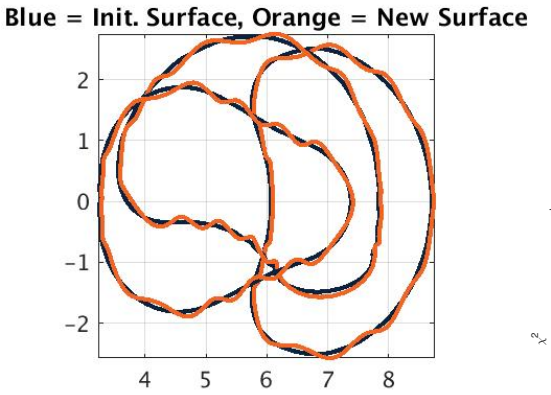


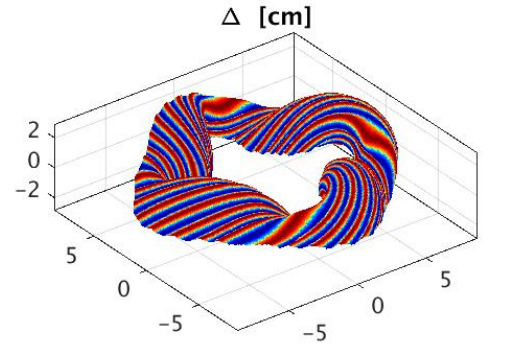


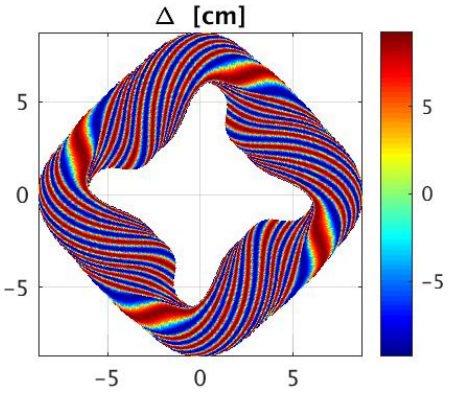


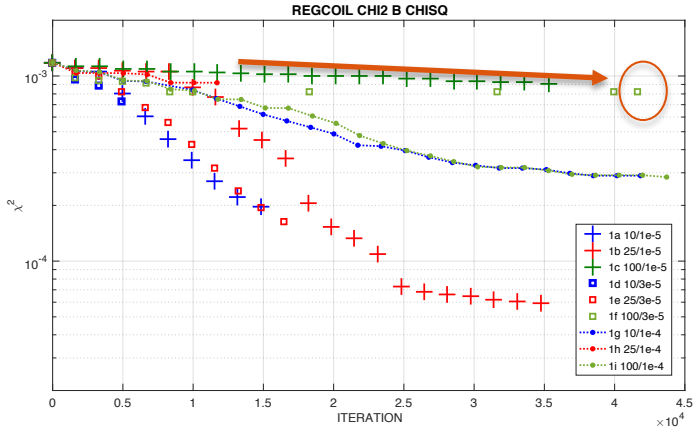
Helical Stripes: The runs that descend very slowly has very corrugated surfaces.





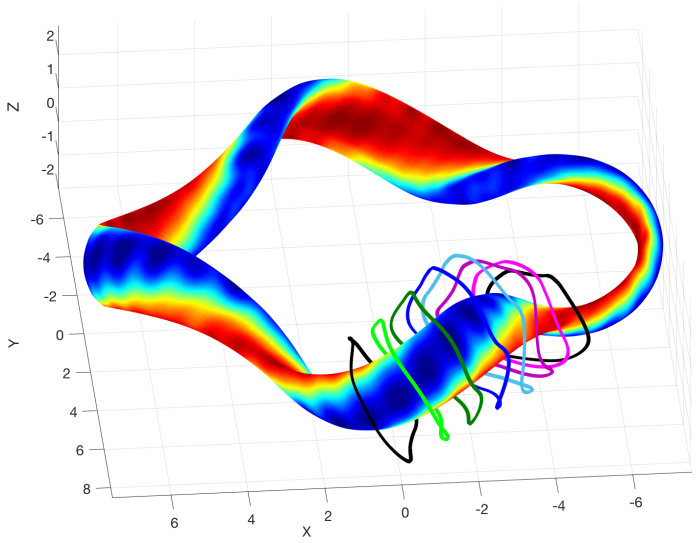


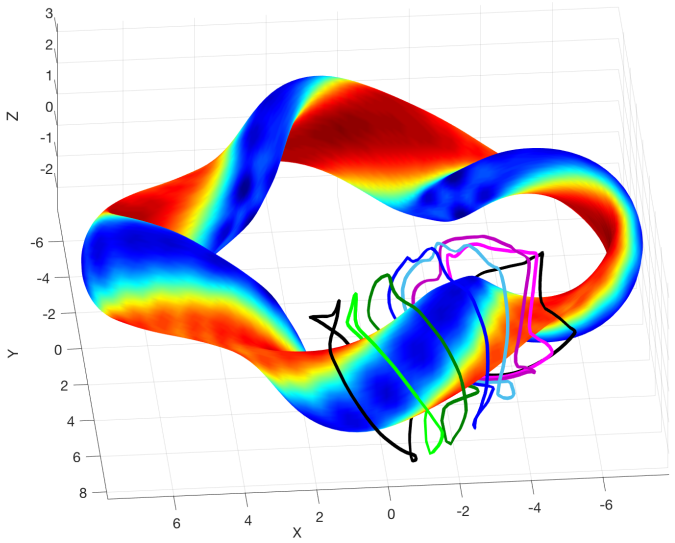





AUBURN
UNIVERSITY

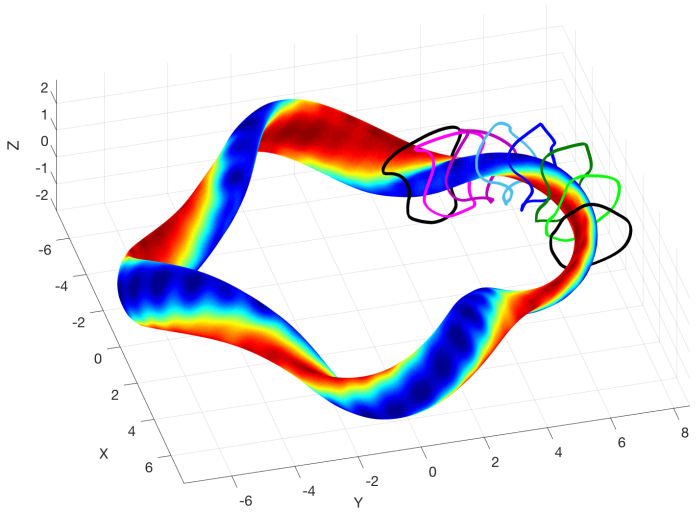
Left: HSX (scaled) Right: QHS46

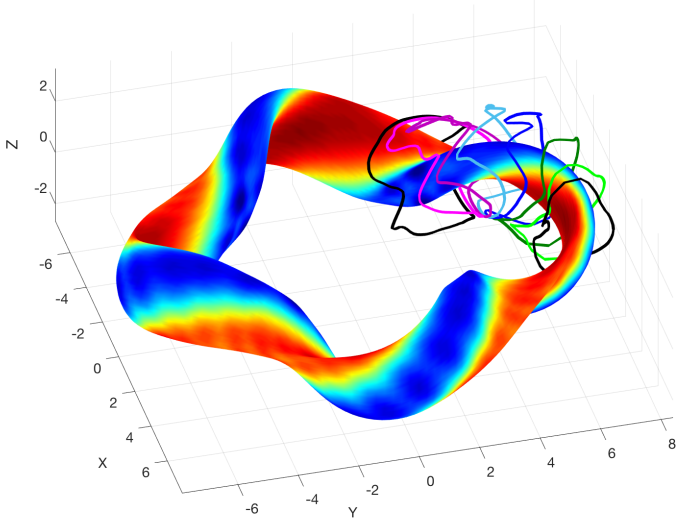




AUBURN
UNIVERSITY

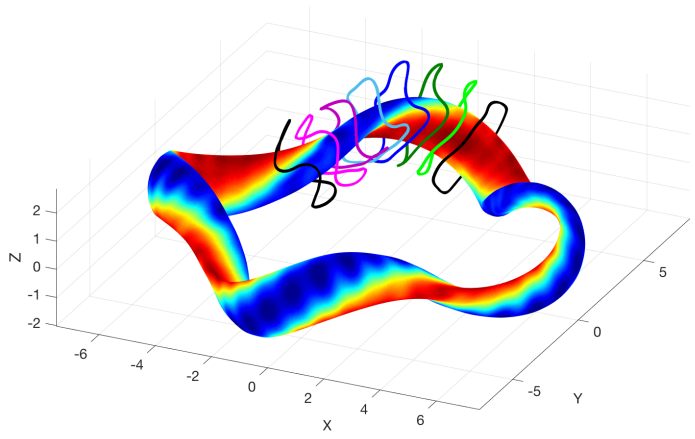
Left: HSX (scaled) Right: QHS46

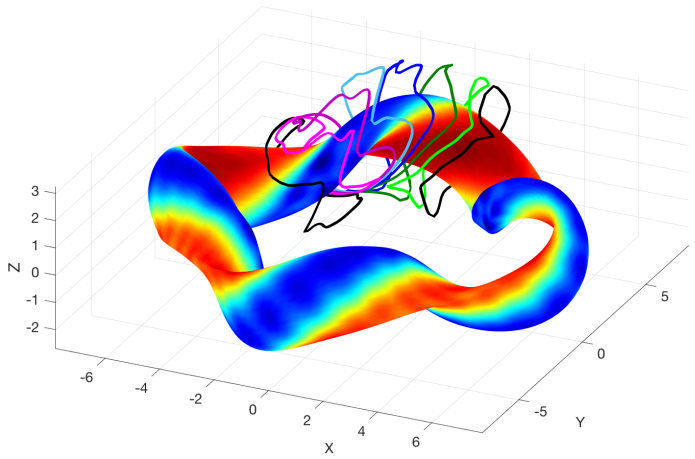




AUBURN
UNIVERSITY

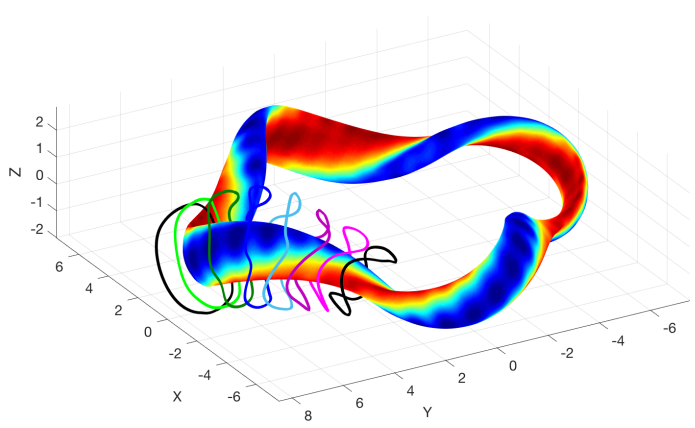
Left: HSX (scaled) Right: QHS46

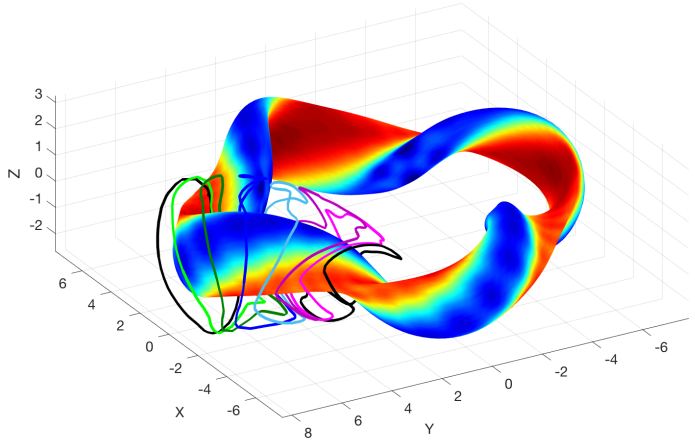




AUBURN
UNIVERSITY

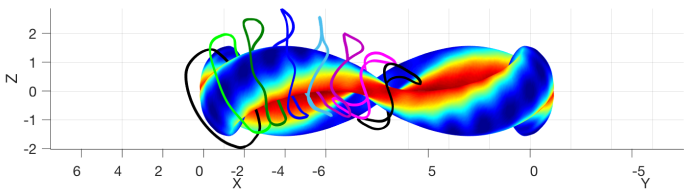
Left: HSX (scaled) Right: QHS46

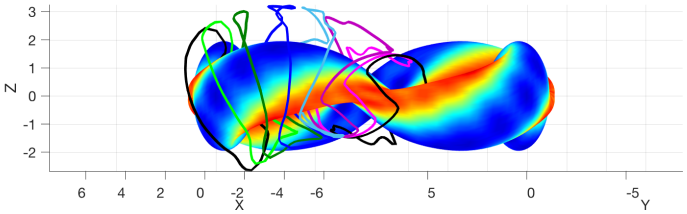




AUBURN
UNIVERSITY

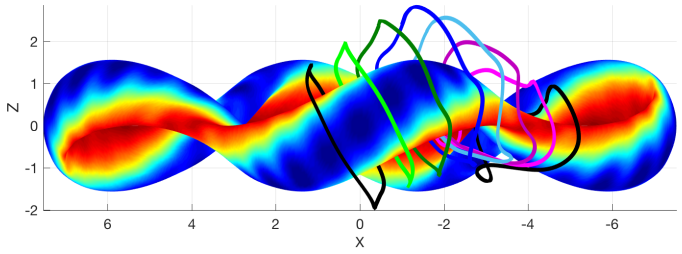
Left: HSX (scaled) Right: QHS46

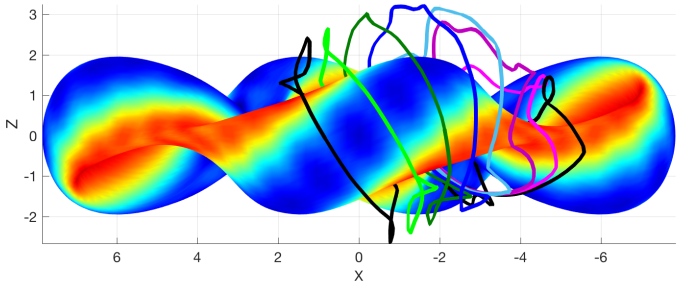




AUBURN
UNIVERSITY

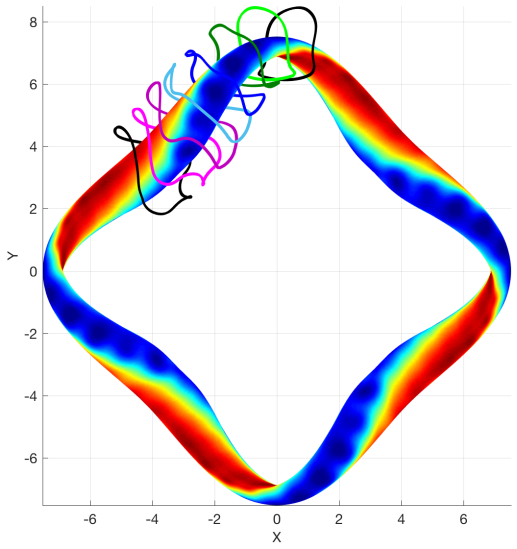
Left: HSX (scaled) Right: QHS46

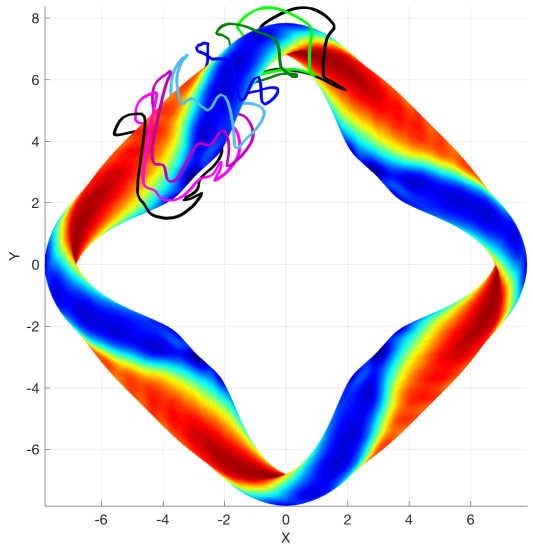




AUBURN
UNIVERSITY

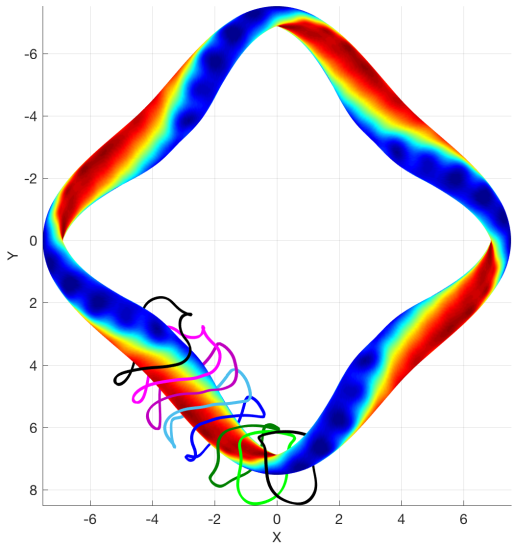
Left: HSX (scaled) Right: QHS46

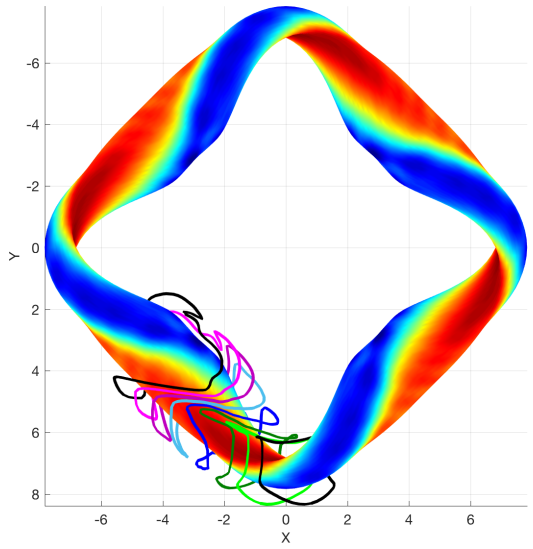




AUBURN
UNIVERSITY

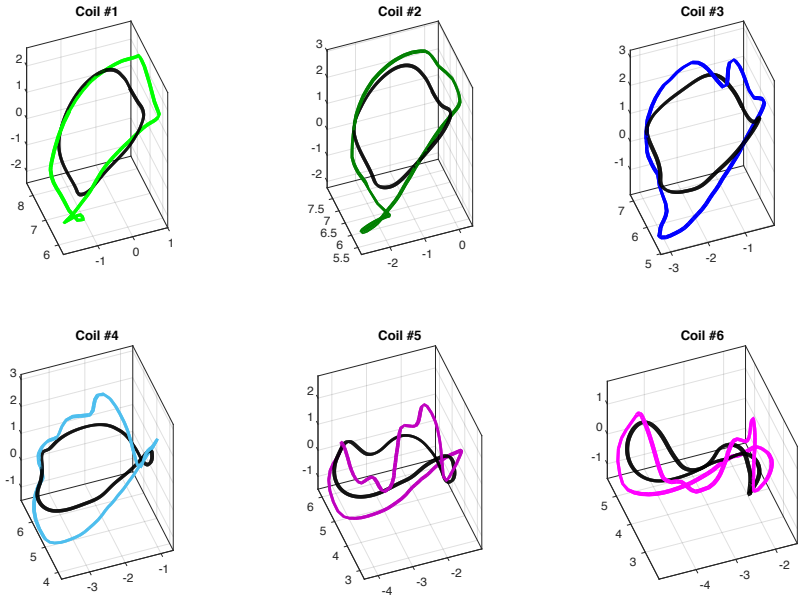
Left: HSX (scaled) Right: QHS46





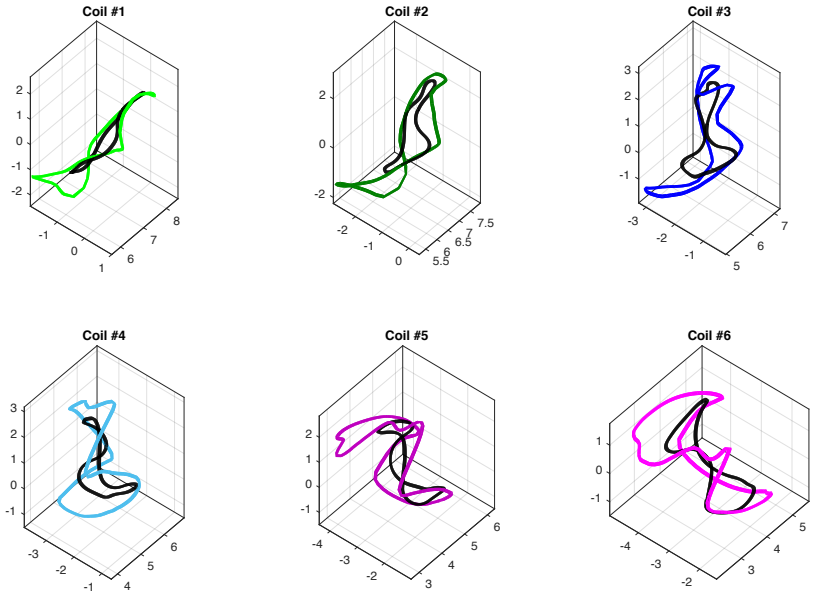
AUBURN
UNIVERSITY

Black: HSX (scaled) coils. Color:QHS46 coils



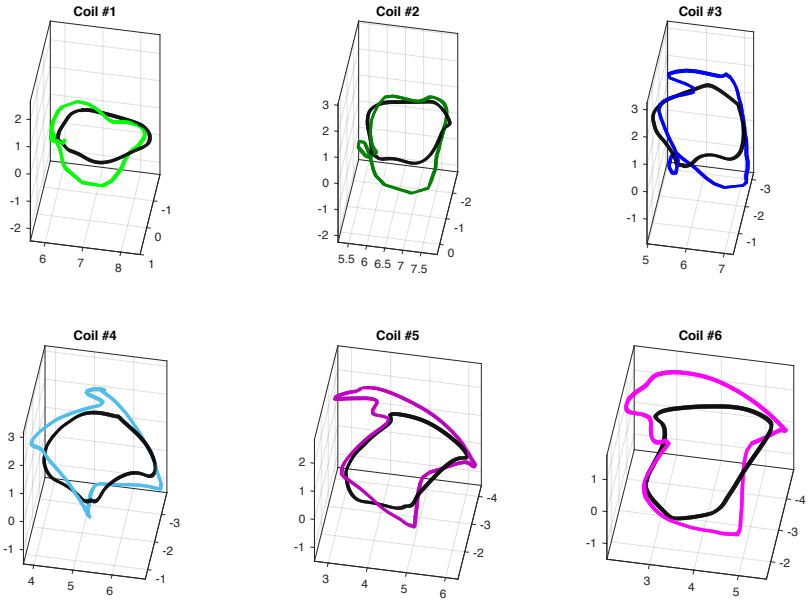
AUBURN
UNIVERSITY

Black: HSX (scaled) coils. Color:QHS46 coils



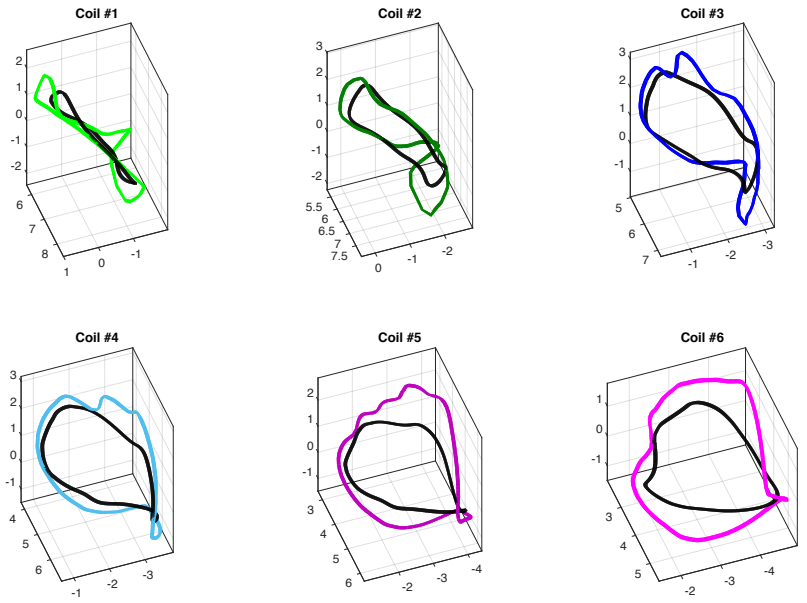
AUBURN
UNIVERSITY

Black: HSX (scaled) coils. Color:QHS46 coils



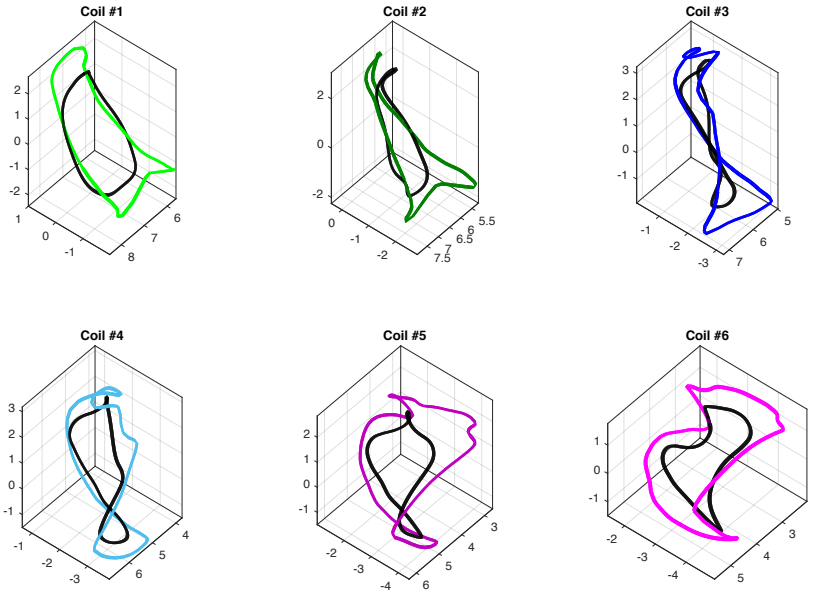
AUBURN
UNIVERSITY

Black: HSX (scaled) coils. Color:QHS46 coils



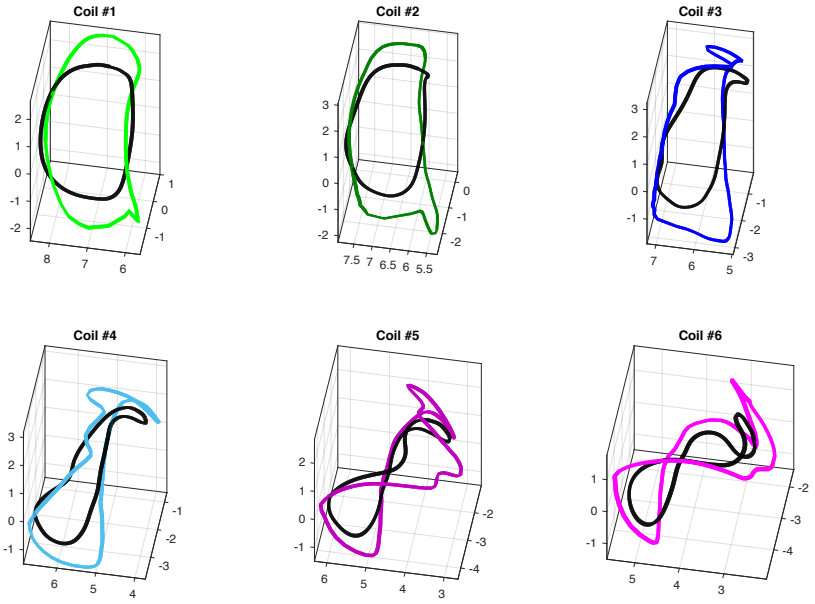
AUBURN
UNIVERSITY

Black: HSX (scaled) coils. Color:QHS46 coils



AUBURN
UNIVERSITY

Black: HSX (scaled) coils. Color:QHS46 coils



AUBURN
UNIVERSITY