Designing for Coil Flexibility

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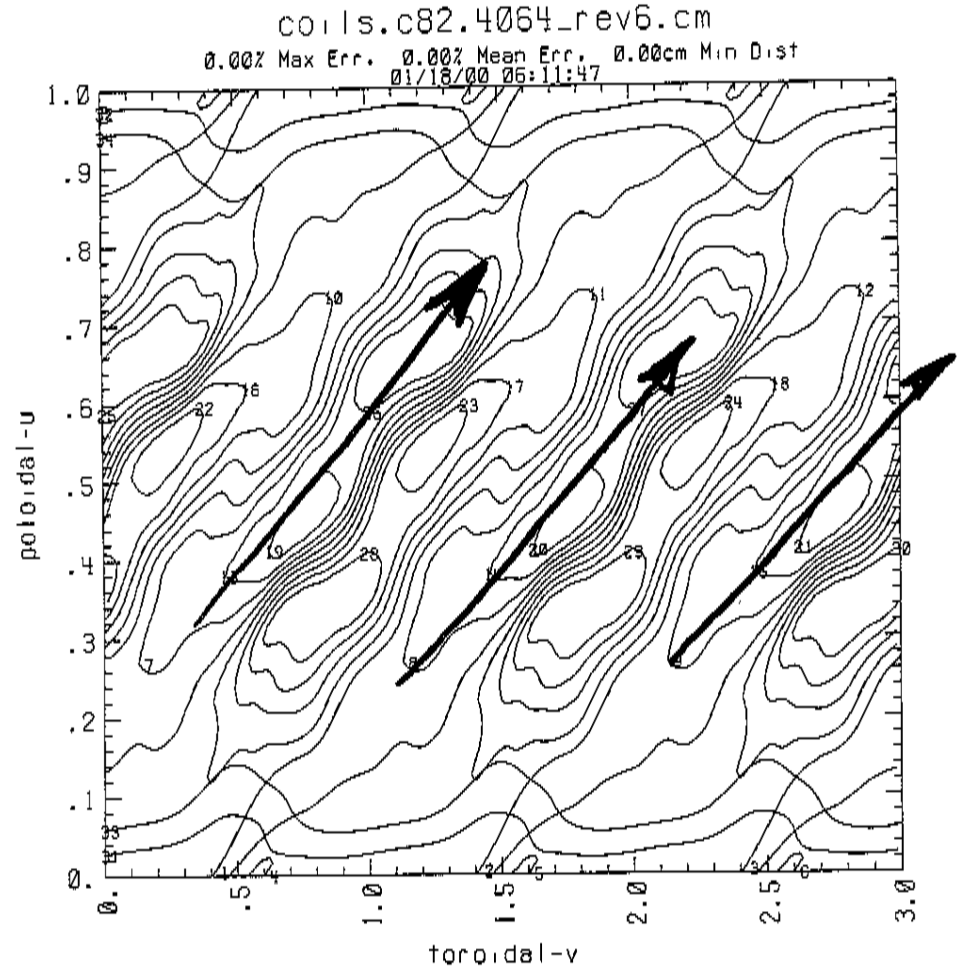
Flexibility:

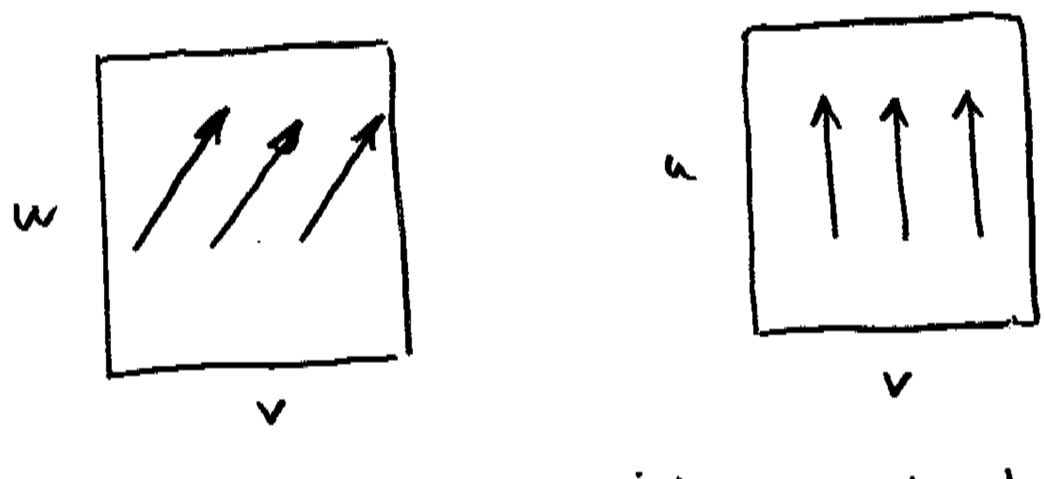
- **Ability of coils to support plasma configurations with dialled in transport and stability properties for a range of profiles.**
- **The plasma shape is one controller of both of these physics elements, therefore we must be able to vary the shape of the plasma in a prescribed way for a prescribed set of profiles.**
- **We seem to be presently hooked in to a philosophy of supporting coils on a winding surface. Therefore an early question to address is**
  - **(Q1) Can we get by with a <u>single</u> winding surface?**

- To address (Q1), run the optimizer with each of the chosen range of profiles to obtain configurations with specified figures of physics merit. (Finding just the optimum configuration is NOT enough–we want to control the physics.). We now have a set, N_{eq}, of configurations that coils must provide.

- For each configuration calculate the current sheet solution, $\kappa_i(u,v)$, ON A FIXED WINDING SURFACE WHICH HAS A MINIMUM SEPARATION FROM ANY ONE OF THESE PLASMAS (ie the winding surface is not conformal with any one of the plasmas).

- Now ask: Is the basic orientation of the contours (coils) preserved as we span the desired range of equilibria? (See Fig 1)
  - If answer is yes, we can probably cut a system of coils from some "average" current sheet, $\kappa_{avge}(u,v)$, and simply vary the current in the individual coils.
  - If answer is no, we need to address the following question:
  - (Q2) How many independent coil systems are needed? Once again, SVD methods can provide an answer (eg., see Allen Boozer's Sherwood Poster):





Schematic of 2 possible current sheet sol^s

Fig 1

- For the fixed coil winding surface we have N_{eq} current potentials, each of which is described by the same set of N_I natural functions but with different coefficients

$$\kappa_i = \sum_{j=1}^{N_I} I_{ij} f_j(u,v) \tag{1}$$

  - Define a set of primary "currents" by

$$I_j^{(p)} \equiv \frac{1}{N_{eq}} \sum_{i=1}^{N_{eq}} I_{ij}. \tag{2}$$

  - form a matrix of difference currents, and subject to SVD analysis:

$$(\delta I)_{ij} = I_{ij} - I_j^{(p)}, \qquad \text{and} \qquad \delta I = F^T \cdot i \cdot G \quad . \tag{3}$$

  - The number of significant singular values of δI (diagonal elements of i) are the number (N_c) of independent surface current distributions that span the flexibility space. The elements of $\vec{g} \equiv G \cdot \vec{f}(u,v)$ are the N_c required surface current distributions (independent coil sets).
  - The current potential that can adequately produce all equilibria is

$$\kappa_i = \kappa_p + \sum_{j=1}^{N_c} I_{ij}^{(c)} g_j(u,v) \tag{4}$$