MAGNETIC SURFACES

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Magnetic Surfaces Can Be Improved If:

1. starting configuration is good enough to calculate $\vec{B}(\vec{\mathbf{X}})$.

   a. Always true for vacuum fields.
   b. Subtle for a plasma equilibrium.

2. islands are small and one can control

$$\left(\frac{\vec{B}\cdot\vec{\nabla}\psi}{\vec{B}\cdot\vec{\nabla}\varphi}\right)_{res}=-\frac{\partial\chi}{\partial\theta}.$$

3. islands are large but one can use trim coils or plasma boundary shape to control magnetic Hamiltonian χ.

Organized Methods For Obtaining Quality Magnetic Surfaces

Always involve a small parameter.

1. Coil design to support a plasma defined by the shape of its boundary:

   a. Adjust boundary shape so magnetic surfaces are good through out plasma.

   b. Design an efficient coil system ignoring magnetic surface issue.

   c. On a surface just outside plasma find the current potential $\kappa(\theta,\varphi)$ that is required to reproduce plasma boundary shape so the magnetic surfaces are good.

   d. Slowly turn off the current potential $\kappa(\theta,\varphi)$ while maintaining surfaces by adding the required helical distortions to the main coil set or by adjusting trim coils.

2. Flexibility studies with a given coil set:

   a. Design coil set so at least one plasma configuration has good surfaces.

   b. Slowly change currents in main coils while adjusting currents in trim coils to maintain surfaces.

3. Clean-up of highly fractured surfaces:

a. From $\vec{B}(\vec{X})$ calculate magnetic Hamiltonian [J. Comp. Phys. 73, 107 (1987)].

b. Vary plasma shape or trim coil currents to find dependence of Hamiltonian on control parameters $\vec{I}$.

c. Let $\chi(\psi,\theta,\varphi) = \chi_o(\psi) + \lambda\,\tilde{\chi}(\psi,\theta,\varphi) + \chi_c\{\psi,\theta,\varphi,\vec{I}(\lambda)\}$ with $\chi_o+\tilde{\chi}$ the field line Hamiltonian of basic coils. χ_c is the correction Hamiltonian due to trim coils or due to resonant changes in the plasma shape. For $\lambda=0$ Hamiltonian has perfect surfaces, $\chi_c(\lambda=0)=0$. Adjust $\vec{I}$ so Hamiltonian keeps good surfaces until $\lambda=1$ using infinitesimal canonical transformation theory.

Required and Useful Tools

1. Method for calculating $\vec{B}(\vec{X})$.
2. Perturbation method for studying equilibrium effects on islands.
3. Code which calculates fake current potential $\kappa(\theta,\varphi)$ needed to restore surfaces in presence of a candidate coil set.
4. Feedback algorithm on $(\vec{B}\cdot\vec{\nabla}\psi)_{res}$ to eliminate islands.
5. Code that implements infinitesimal canonical transformation method of restoring highly fractured surfaces.

Early Assessments Needed

1. How wimpy are the trim coils?

   Current scales as $(r_c/r_s)^m$ so a small perturbation tends to give a major current for $m > 10$. How high an m can we control?

2. MHD equilibrium effects on islands.

3. Are islands sufficiently small in important cases that simple feedback on $(\vec{B} \cdot \vec{\nabla} \psi)_{res}$ is all that is needed?