DESIGNING COILS TO PRESERVE GOOD MAGNETIC SURFACES

(Resonance Reduction Initiative)

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EARLIER EFFORTS TO AVOID RESONANCES

•**<u>J.Hanson</u> (7September1999 NCSX ProjectMeeting) proposed evaluation inside a design optimization loop of the resonant term** $C = \frac{B_1^s}{B_0^\varphi} = \frac{B_1 \bullet \nabla s}{B_0 \bullet \nabla \varphi}$ **on internal low order rational flux surfaces, where 0,1 subscripts denote primary and perturbation fields.**

•**<u>A. Brooks</u> (9December1999 PhysicsMeeting, IslandSuppressionEfforts) used** $C = \frac{B_1^s}{B_0^\varphi} = \frac{B_1 \bullet \left(\frac{\partial \vec{r}}{\partial \theta} \times \frac{\partial \vec{r}}{\partial \varphi} \right)}{\left(\frac{\partial \Phi(s)}{\partial s} \right)} = B_1 \bullet \left(\frac{\partial \vec{r}}{\partial \theta} \times \frac{\partial \vec{r}}{\partial \varphi} \right) \Big/ \Phi(1)$ **and** $ds = 4 \left| \frac{C_{mn}(s)}{m\iota'(s)} \right|^{1/2}$**.**

Only initial results were produced. They showed large sacrifices in boundary B•n were required to drive calculated island size down.
A. Brooks suspected the large B changes distorted targeted resonant surfaces, and that they would have to be recalculated in the algorithm, which would compromise the benefits of a linear approach.

NEW ALGORITHM

•Instead of using the normal component of "vacuum" field produced by proposed external coils on critical flux surfaces, the new algorithm uses the <u>difference</u> between the normal fields produced by proposed external coils and by an ideally perfect external current distribution.

•The <u>hope</u> is that by using this difference field, perturbations will remain small enough that nonlinear effects can be neglected.

•(1)In the new algorithm, a set of critical low order rational flux surfaces are first automatically chosen using a list of important rational numbers, the "wout" file from a vmec run, and cubic spline interpolation subroutines. Also, $\frac{\partial \iota}{\partial s}$ is calculated on each surface.

•(2)Critical surface fourier coefficients are interpolated using splinefits.

NEW ALGORITHM (2)

•(3)The xyz coordinates of uniformly spaced (θ,φ) gridpoints on each surface are calculated, along with the vectors, $\vec{v} = \left(\frac{\partial \vec{r}}{\partial \theta} \times \frac{\partial \vec{r}}{\partial \varphi} \right) \Big/ \Phi(1)$

•(4) A set of proposed external current pattern descriptions are read from "coils" files. One pattern (number 0) is of the ideal "coil winding surface" current distribution best matching vmec's required bnormal distribution. Each of the others is for a coil input to the GA algorithm.

•(5)For each 1 ampere external current pattern (j) and for each critical flux surface (i), the algorithm calculates $C^{i,j} = \tilde{B}^{i,j} \bullet \vec{v}$ at each grid point.

• (6)Fourier coefficients in vmec coordinates, $C^{i,j}_{m,n}$, are calculated, then converted to "straight-line" uv coordinates using P. Valanju's "b2xpp" algorithm. The full set of coefficients are written to a file.

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•(7)The GA algorithm reads the coefficients. Resonance on the ith surface is $C^{i}_{mn} = \sum_j C^{ij}_{mn} I_j - C^{i0}_{mn} I_0$ where the GA determines coil currents, $\{I_j\}$.

PRESENT STATUS, PROGNOSIS, CONCLUSION

•Items (1)-(3) above, have been coded and tested.

•Items (4)-(5) above, have been coded for collections of filament loops. Testing is in progress.

•Item (6) above coding is in progress to use P. Valanju's algorithm for conversion between vmec and straight-line coordinates.

•Item (7) above has been planned but not coded. Its implementation within the GA code is expected to involve the main cognizant person for the GA code, W. Miner. It appears to be a straight-forward addition.

•Algorithm is almost complete. Closer collaboration with UTexas will speed completion and evaluation of this algorithm. It is not known how effective this targeting algorithm will be in practice. Evaluation and subsequent use for resonance reduction will be in conjunction with use of the GA algorithm, for which W.Miner has been the primary user.