Control and Optimization of the Vacuum Field Configuration in Compact Stellarators

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The suppression of vacuum magnetic islands due to low order resonances is demonstrated in compact stellarators. Magnetic field lines in stellarators are 1-1/2 degrees of freedom Hamiltonian systems which are in general non-integrable and may exhibit chaos. Of particular interest are magnetic islands which, by resonance overlap, can give rise to chaos that results in poor plasma confinement. Accordingly, it is important for stellarator optimization to develop techniques to control the location and size of islands. In the present work, the magnetic field is due to a set of filamentary stellarator coils, including modular, vertical field, and toroidal field windings. By following magnetic field line orbits in a stellarator symmetric system, periodic orbits of order $m=N/\iota$ (for N-field period symmetry) are located in a toroidal symmetry plane. Following [1], the tangent map is calculated for each periodic orbit (fixed point of the composed return map), and the residues [2], a measure of island size, are targeted in a nonlinear optimization. For prescribed modular coil geometry, major island chains in the National Compact Stellarator Experiment (NCSX) and Quasi-Poloidal Stellarator (QPS) vacuum configurations can be significantly reduced in size by varying only coil currents. These techniques will be used to determine island size [3] in compact stellarators. The optimization will be extended to reduce islands resulting from winding geometry errors in NCSX and QPS by varying the orientation of modular coils in array, e.g., through small shifts and rigid-body rotations.

[1] J.R. Cary and J.D. Hanson, Phys. Fluids **29**, 2464 (1986).
[2] J.M. Greene, J. Math. Phys. **20**, 1183 (1979).
[3] J.R. Cary and J.D. Hanson, Phys. Fluids B **3**, 1006 (1991).