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Development of a Robust Class of Quasi-Poloidal Compact Stellarator Configurations

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A compact quasi-poloidally symmetric stellarator plasma and coil configuration is described that has desirable plasma properties and a large volume bounded by good magnetic flux surfaces for both vacuum and 2% beta. The configuration is robust insofar as variations of the plasma beta and consequent bootstrap current leave the bounding flux surface nearly intact, minimizing the need for active positional control. This configuration was developed using a new computational method targeting good vacuum flux surfaces, as a measure of robustness, in the design of magnetic coils. The recently combined[1] stellarator plasma and coil design codes STELLOPT and COILOPT are used to vary coil geometry and plasma profiles to optimize free-boundary 3-D equilibria with respect to neoclassical transport, infinite-n ballooning stability, and coil engineering parameters (e.g., coil-plasma and coil-coil separation, minimum coil radius of curvature), while simultaneously minimizing the term $\chi_B = \omega_B |\mathbf{B}\cdot\mathbf{n}|/|\mathbf{B}|$ in the STELLOPT objective function. Here, **n** is the normal to the full-pressure plasma boundary and **B** is the *vaccum* magnetic field due to the coils. This vacuum field constraint, together with recent changes in the coil model, has resulted in an improved plasma and coil configuration for the Quasi-Poloidal Stellarator (QPS). In particular, the plasma volume enclosed by good vacuum magnetic surfaces is equal to, or greater than, that of the full-beta plasma with only insignificant islands. This implies a preservation of aspect ratio as beta is increased, an important feature in QPS since experiments that focus on neoclassical transport will take place at low beta. Coil design features include 1) a reconfiguration of the modular coils in QPS, reducing the number of coils from 16 to 10, and the number of coil winding forms from 4 to 3, and 2) improved engineering feasibility, due to increased coil separation and minimum coil radius of curvature.

1. D. J. Strickler, L. A. Berry, S. P. Hirshman, et al., "Integrated Plasma and Coil Optimization for Compact Stellarators," 19th IAEA Fusion Energy Conference, Lyon, France (October, 2002).

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