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Delta-W Calculation of Magnetic Islands in Plasma Equilibria

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The identification and elimination of magnetic islands are major issues for three dimensional plasma equilibria. We have shown that the Delta-W code CAS3D can be used to identify magnetic islands and could be used to construct plasma equilibria that are essentially island free. The minimization of Delta-W can be expressed as the minimization of a quadratic functional of the radial plasma displacement. The resonant Fourier components of the minimizing radial plasma displacement are generally discontinuous at rational surfaces. The magnitude of this discontinuity is proportional to the current that must flow on the rational surface to prevent an island from opening. In other words, the jump in the radial displacement is proportional to the square of the width of the island that would arise without the singular current. The effect on magnetic islands of various displacements of the plasma surface can be determined by minimizing Delta-W with fixed radial displacements at the plasma surface. This has been done using the CAS3D code. This code could also be used to test the quality of the surfaces in an equilibrium calculated assuming perfect magnetic surfaces and could determine the modifications in the plasma shape that are required to have good surfaces. A given set of nested toroidal magnetic surfaces is consistent with a scalar pressure equilibrium except for a radial force on each magnetic surface. The presence of this radial force modifies Delta-W. A minimization of the modified Delta-W determines the radial displacement that would be required to have a true equilibrium. If the minimizing radial displacement is chosen to vanish at the plasma edge, then jumps at the rational surfaces imply the true equilibrium has islands. However, the radial displacement at the plasma edge can be chosen to eliminate the jumps at rational surface and hence the islands. This modified equilibrium is a neighboring equilibrium with good magnetic surfaces.