Subject 1

Ergodisation of the Magnetic Field in W7AS Stellarator Equilibria with Increasing β

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Equilibria for the W7AS stellarator calculated with the PIES 3D equilibrium code display a region of chaotic field line trajectories at the plasma edge when β is raised above a threshold value, and the width of the ergodic region increases as β is further increased. To calculate self-consistent 3D equilibria, including the pressure driven current in the ergodic region, it is necessary to solve a magnetic differential equation along chaotic field line trajectories. We show that this equation is mathematically equivalent to the collisionless Vlasov equation in the presence of electrostatic turbulence, allowing us to apply the mathematical techniques of resonance-broadening theory.

The field lines in the ergodic region of the calculated equilibria are found to have an interesting structure, behaving as if the flux surfaces are broken only locally near the outer midplane and are preserved elsewhere. This is consistent with the intuition that the flux surfaces are broken due to the strong compression and deformation produced by the Shafranov shift near the outer midplane.

We focus particularly on a detailed comparison of two W7AS shots which differ only in the magnitude of the current in the divertor control coil, but have very different values of experimentally attainable β ($\langle\beta\rangle \approx 2.7\%$ vs. $\langle\beta\rangle \approx 1.8\%$). The divertor control coil has been constructed to influence the resonant components of the magnetic field near the plasma edge, and has little effect on the macroscopic properties of the plasma such as the rotational transform, the ripple transport, and the Shafranov shift. Equilibrium calculations find that a region of chaotic magnetic field line trajectories fills approximately the outer 1/3 of the cross section in each of these configurations. The calculated magnetic field line diffusion coefficients for the two shots, and the corresponding estimates of the contribution of field line stochasticity to thermal transport, are consistent with the observed differences in the attainable β, and also consistent with the differences in the reconstructed pressure profiles.