Plasma Confinement in the Vicinity of a Magnetic Island in Toroidal Plasmas

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Magnetic islands are nearly ubiquitous in magnetically confined plasmas. They play an important role in fusion plasmas through their effect on plasma confinement. For example, low *m* neoclassical islands limit the plasma beta, which is the ratio of plasma pressure to magnetic field pressure, in fusion grade plasmas. Here, *m* is the poloidal mode number. When magnetic islands are present, the equilibrium symmetry in the magnitude of the magnetic field $B = |B|$ is broken. The broken symmetry in B is, however, usually ignored. This is because the symmetry breaking effect on B is thought to be of order $(\delta B/B)^2 << 1$. However, if B is not spatially uniform, *e.g.*, $B=B(x)$, with x the radial variable, the symmetry breaking effect in B is of the order of $B'(x_0)(\Delta x)$, Here, x_0 is the position of the singular layer, prime denotes d/dx, and Δx is the width of the island. Because Δx is proportional to $(\delta B/B)^{1/2}$, the symmetry breaking effect becomes much more important than previously perceived. A transport theory including particle, heat, and momentum transport, in the vicinity of a magnetic island in tokamaks has been developed. We discuss the implications of this broken symmetry in B on plasma confinement in the vicinity of a magnetic island, and extend the theory to a rotating island. The theory may play a role in the confinement improvement in the vicinity of the low order rational surfaces observed in tokamak experiments. The symmetric breaking effect could be enhanced further in low aspect ratio tokamaks when islands are present.

This work was supported by US Department of Energy under Grant No. DE-FG02-01ER54619 with the University of Wisconsin.