MHD Activity Induced Toroidal Flow Damping

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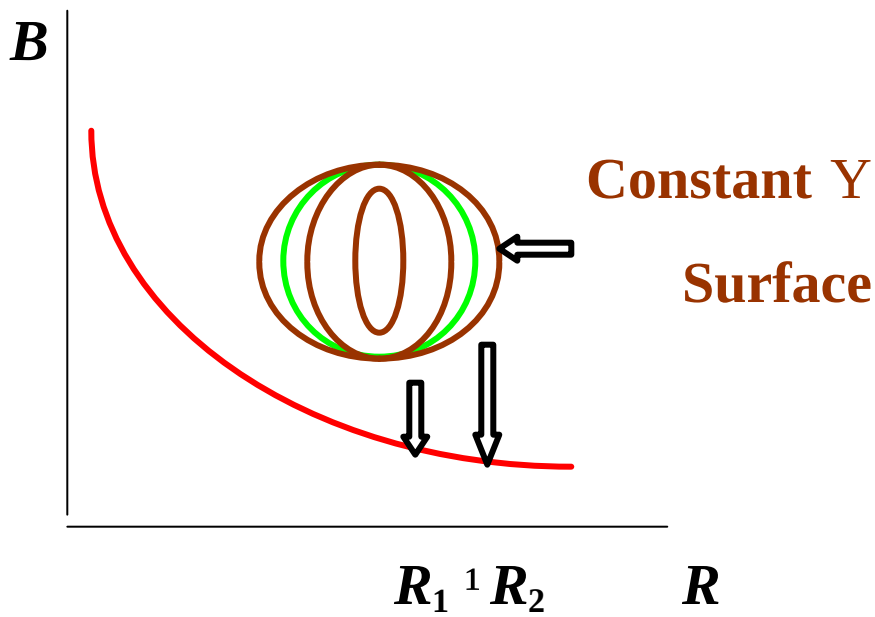
Outline

- **Toroidal symmetry in $|B|$ is broken, when MHD activity, such as magnetic islands, or resistive wall modes, is present.**
- **This leads to enhanced toroidal momentum damping.**
- **Integrated modeling: merge transport modeling with the effects of MHD activity included.**
- **Conclusions.**

Variation of |*B*| on Island Magnetic Surface (Resonant Perturbation)

- 

- **|*B*| on the island surface:**

$$B/B_0 = 1 - \left[\frac{r_s}{R} \pm \frac{r_w}{R}\left(\overline{\Psi} + \cos x\right)^{1/2}\right]\cos q$$

$\overline{\Psi}$ **: Normalized helical flux function,**
x : ***m*** (q - z / q_S)**, helical angle,**
m **: Poloidal mode number,**
q_S **: Safety factor at rational surface,**
z **: Toroidal angle,**
r_w**: A measure of the width of the island,**
r_s **:** ***r*** **at the rational surface.**

Effects of |*B*| Variation on Island Surface

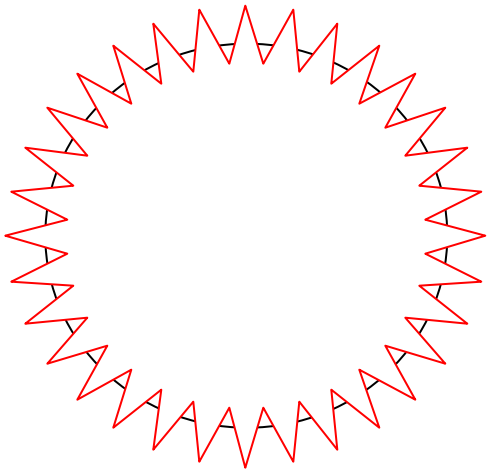
- **Similar to a rippled tokamak except this occurs in the hot plasma core.**

- **This leads to enhanced plasma transport and momentum dissipation over those of the standard neoclassical theory.**

- **In general, 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.**

Non-Resonant MHD Activity

· **For example, resistive wall modes. In this case, MHD perturbations just distort magnetic surface (no island formation).**



· **Breaks the toroidal symmetry in |*B*|**

· **This also leads to enhanced toroidal momentum damping.**

Modeling of Toroidal Flow in the Presence of MHD activity

· **Using classical, and anomalous toroidal viscosity to model equilibrium toroidal flow profiles.**

· **Using stelarator-like toroidal viscosity to model toroidal flow profiles after the onset of the MHD activity, such as the appearance of the magnetic islands, or resistive wall modes.**

Integrated Modeling

· **Extend NCLASS to model toroidal momentum confinement to include both neoclassical and anomalous toroidal viscosity.**

· **Including effects of MHD activity on toroidal flow damping.**

Conclusions

· **Toroidal symmetry in |B| is broken in the presence of MHD activity.**

· **This leads to enhanced toroidal momentum damping.**

· **This can be modeled by using stellarator-like toroidal viscosity in NCLASS.**