

EFFECT OF MAGNETIC SHEAR ON DESTRUCTION OF GOLDEN MAGNETIC SURFACE IN DIVERTOR TOKAMAKS

Halima Ali¹ and Alkesh Punjabi¹

¹Hampton University, Hampton, VA, 23668, USA

ABSTRACT: A symplectic logarithmic map in magnetic coordinates is used to calculate the effect of magnetic shear on the critical level of magnetic perturbation that destroys the golden magnetic surface in divertor tokamaks. The parameter s in the map controls the magnetic shear. The equilibrium magnetic surface with golden value of magnetic safety factor, q_{gold} , is calculated as a function of magnetic shear s . Magnetic perturbations (4,3)+(2,1) with resonant surfaces just above and below these golden surfaces is studied. These magnetic perturbations are applied with increasing amplitudes and the critical amplitude when the golden surfaces break down is calculated for different values of magnetic shear s . There is competition between the closer proximity of resonant surfaces and the magnetic shear. The results of this study will be presented.

We report the preliminary results on the scaling of critical amplitude of magnetic perturbation, δ_{crit} , with magnetic shear s for the destruction of the golden magnetic surface Ψ_{golden} in divertor tokamaks when the resonant surfaces of the perturbing modes are more symmetrically placed relative to the golden surface. In our previous work, we had found that δ_{crit} scales as $e^{-s/3}$ for the modes (2,1) + (3,2) using our new logarithmic shear map [1]. In this case, for $s=0.7$, the resonant surfaces were $\Psi_{21}=0.7603$ and $\Psi_{32}=0.5105$, and $\Psi_{golden}=0.5864$, and the distances of resonant surfaces from the golden surface were $\Psi_{21} - \Psi_{golden} = 0.1739$ and $\Psi_{golden} - \Psi_{32} = 0.0759$. So the resonant surfaces were placed quite asymmetrically about the golden surface, and the degree of asymmetry can be characterized by the ratio of the distances $0.1739/0.0759 \approx 2.3$. Note that the magnetic coordinates, magnetic fluxes, and distances in magnetic coordinates are all normalized by the toroidal magnetic flux Ψ_{SEP} inside the separatrix surface where the safety factor $q=\infty$. In this paper we use the perturbing modes (2,1) + (4,3) with resonant surfaces $\Psi_{21}=0.7603$ and $\Psi_{43}=0.3789$ for $s=0.7$, the distances are $\Psi_{21} - \Psi_{golden} = 0.1739$ and $\Psi_{golden} - \Psi_{43} = 0.2075$, and the ratio of distances is $0.1739/0.2075 \approx 0.84$. The resonant surfaces are more symmetrically placed about the golden surfaces, see Fig. 2. Fig. 1 shows the equilibrium safety factor and equilibrium generating function when $s=0.7$.

Recently [1,2] we constructed a symplectic map in magnetic coordinates that calculates magnetic field line trajectories in single-null divertor tokamaks with variable shear. We used this map to study the resilience of golden magnetic surface in tokamaks against resonant magnetic perturbations. The parameter s in this map controls the magnetic shear. The mapping technique [3] is applied to integrate the field lines of toroidally confined plasma. As the magnetic shear parameter s is increased from 0.7 to 3.5, the critical levels of the perturbations δ_{crit} when the golden surfaces Ψ_{golden} break down are calculated

We found that the critical amplitude δ_{crit} scales as $e^{-s/3}$ when the resonant surfaces of the perturbing modes are more symmetrically placed relative to the golden surface. See Fig. 3. Comparison of this result and our previous result in [1] indicates that the asymmetry in the placement of the resonant surfaces about the golden mean does not seem to play a role on this scaling.

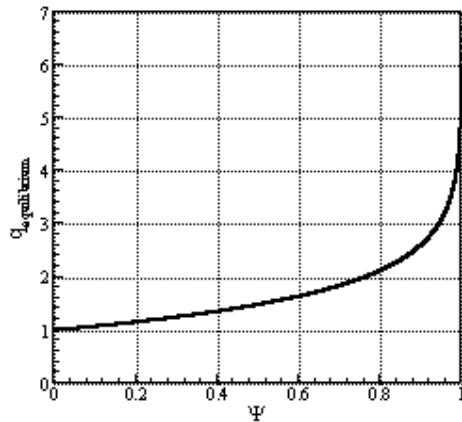


Fig. 1(a) The equilibrium safety factor when $s=0.7$

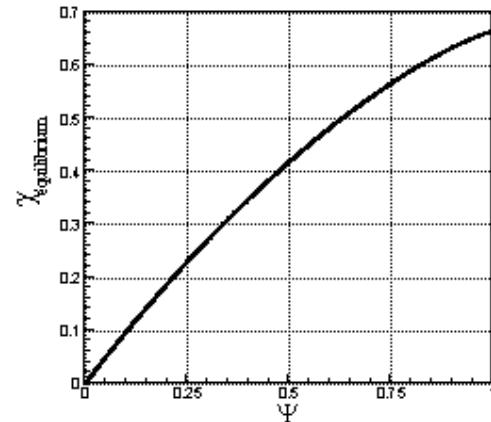


Fig 1(b) The equilibrium generating function when $s=0.7$

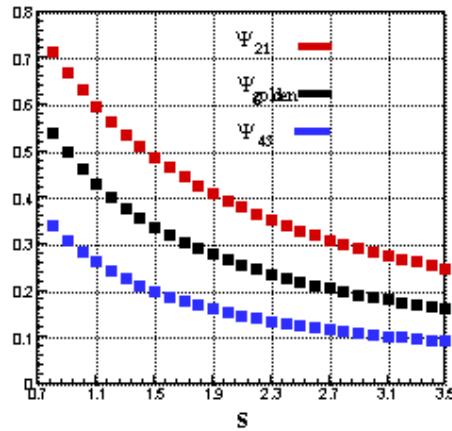


Fig. 2(a) Resonant and equilibrium golden magnetic surfaces as a function of the shear parameter s

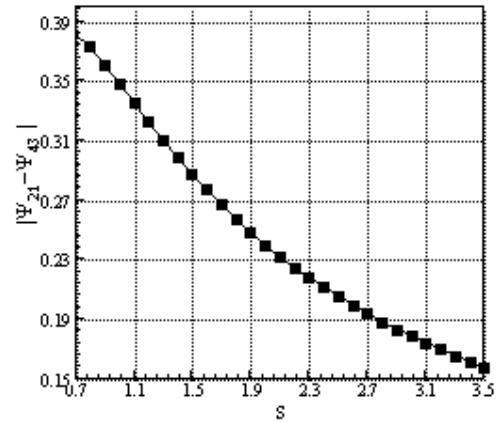


Fig. 2(b) Distance between resonant magnetic surfaces as a function of the shear parameter s .

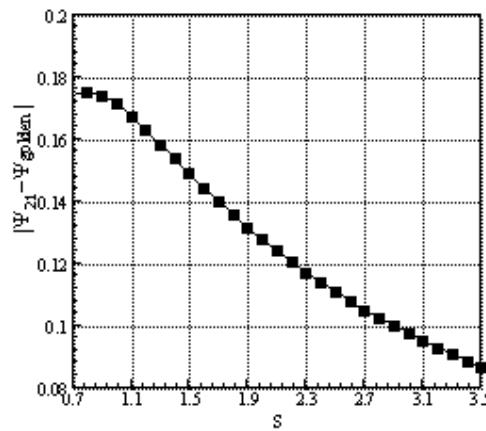


Fig. 2(c) Distance between resonant magnetic surface (2,1) and equilibrium golden surface s as a function of the shear parameter s .

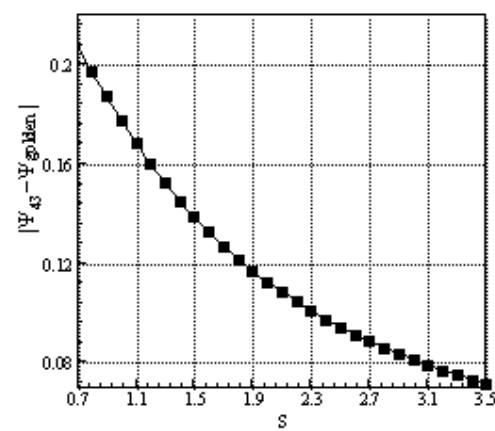


Fig. 2(d) Distance between resonant magnetic surface (4,3) and equilibrium golden surface s as a function of the shear parameter s .

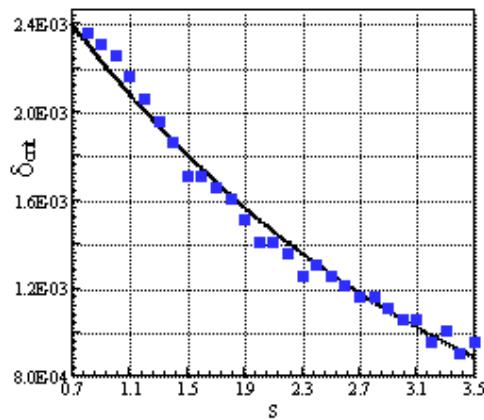


Fig. 3. The critical amplitude, δ_{crit} as a function of the shear parameter s .

Curve through data point is an exponential fit: δ_{crit} scales as $e^{-s/3}$.