§69. MHD Property for FFHR

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We have studied the MHD equilibrium and stability and the neoclassical transport property of FFHR ($l=3/m=18, R_C=20m$, $a_C=3.33m$, $\gamma_C=1.0$) with some magnetic axis.

1. Vacuum Magnetic Surface

The plasma aspect ratio of FFHR is about 10. Straight l=3 helical system has zero rotational transform in the plasma center as well known. Since FFHR is slender l=3 helical system, its rotational transform is nearly zero in the case that its magnetic axis is near device center. FFHR is sensitive to quadrupole magnetic field component from helical coil or/and poloidal coils, and its magnetic axis is likely to split, which isn't unfavorable aspect according to the prediction that pressure profile become flat in the region where the magnetic axis splits. However, the magnetic axis tourus inward or outward shifts prevent it from splitting magnetic axis.

2. MHD Equilibrium and Stability Analysis

The MHD equilibrium of FFHR with various vacuum magnetic axes is calculated by VMEC code. All configurations with $R^V_{ax}=18.7\sim20.8m$ have almost same equilibrium beta limit, $\beta_0\approx4\%$. Here, we decide the equilibrium beta limit from the convergence condition of VMEC.

MHD stability is estimated by Mercier analysis. Figure 1 shows stability beta limit with various magnetic configuration. Stability beta limit is defined by the condition that the region $D_I>0.2$ does not exist, where D_I corresponds to $D_I=-1/4$ in vacuum. $D_I>0$ corresponds to the Mercier mode (high m limit) unstable and $D_I>0.2$ to the low-n mode unstable. The configuration with R_{00} (a) $\approx$20.1m has the stability beta limit 2%, which corresponds to the ignition condition for $B_0=12T$.

3. Neoclassical Ripple Transport

Figure 2 shows the geometric factor of helical ripple loss for FFHR estimated by means of multi-helicity model of ripple transport. Here G is the geometric factor, where is equal to $\varepsilon^2_t\varepsilon^{3/2}_h$ for simple magnetic field model. For FFHR, geometric factor decreases as magnetic axis shifts outward, which is different from the property of l=2 helical system. This is why that the side band of Fourier component of main helicity in FFHR is l=2/4 and change of quadrupole component is dominant effect here.

We get the results that magnetic field configuration with certain outward tourus axis shift is favorable for both MHD equilibrium and stability, and neoclassical ripple transport in FFHR

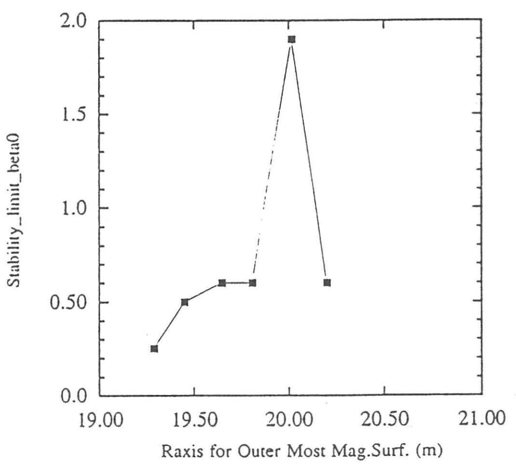

Fig.1 MHD stability beta limit for various FFHR configuration.

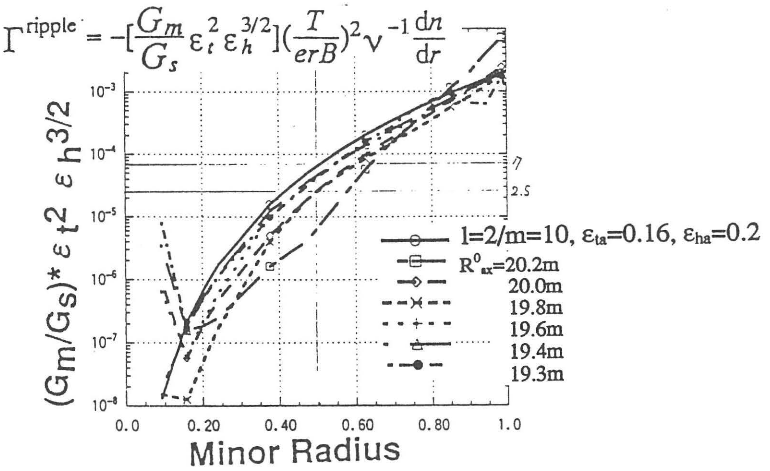

Fig.2 Geometric factor of helical ripple transport in various vacuum FFHR configuration.