§28. Role of Ideal Interchange Instability on LHD Experiments

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In heliotoron devices, the magnetic axis torus-inwardly shifted is good direction on neoclassical transport and/or high energy particle confinement, however, it is bad direction on MHD stability like as the ideal interchange mode. In order to look for the condition that the above properties are compatible, we study the MHD stability properties in the configuration with R_{ax}=3.5m magnetic axis, which corresponds to the magnetic axis torus-inwardly shifted. Here, we analyze the relationship between the operational regime of the pressure gradient and the linear low-n ideal MHD unstable region theoretically predicted. We have already studied the similar analysis for 3.6m configuration[1], which is more stable on ideal interchange mode and where the operational regime of the pressure gradients does not violate the low-n unstable region except transient phenomena like as the pellet injection.

Figure 1 shows the achieved pressure gradient at ρ=0.4 in 3.5m configuration with β-dβ/dρ diagram. Open circles and closed triangles denote data under cntr.-NB injection and co-NB injection. Solid line shows the low-n ideal MHD mode unstable region. The low-n ideal MHD mode unstable region for 3.5m configuration is much larger than that for 3.6m configuration. Both the achieved pressure gradient under cntr.- and co- NB injection is deeply in the low-n ideal MHD mode unstable region predicted theoretically, which leads to the fact that the low-n ideal MHD mode does not limit the operational regime on the pressure gradient at the core region in 3.5m configuration. This situation is quite different from that for 3.6m configuration.

The big difference of the configuration properties between 3.5m and 3.6m configurations is the rotational transform and its shear in the core region. The rotational transform is a little larger and its shear is smaller in 3.5m configuration than those in 3.6m configuration, which leads to the larger effect of the toroidal current on the position of rational surface in the core region, especially ι=1/2. According to the theoretical analysis about the effect of toroidal current on the low-n ideal MHD mode at the core region of 3.5m configuration, the stable region of pressure gradient on the low-n ideal MHD mode extends widely due to large positive toroidal current with more than 20kA/T. Here, the data in Fig.1 corresponds to the cases with various toroidal current from -5~60kA/T.

In order to study the effect of toroidal current on the low-n ideal MHD stability for the core region of 3.5m configuration, the dependence of Mercier parameter on beta at ι~1/2 is shown in Fig.2. Open circles and closed triangles denote data under cntr.-NB injection and co-NB injection. The closed circles below D_I=0 corresponds to the cases without resonant rational surface (ι=1/2). Here, we assume $j=j_1*(1-\rho^2)^2 + j_2*(1-\rho^2)*\rho^2$ as the troidal current profile. The 1st and 2nd terms denote the beam driven current and bootstrap current, respectively. The bootstrap current is assumed to be 13.3kA/T. j_1 is decided as the net toroidal current coincides with measurement. Open triangles and squares correspond to the cases that resonant rational surface disappear when $j=j_1*(1-\rho^2)$ and $j=j_1*(1-\rho^2)^2$ are assumed, respectively. Mercier parameters are around 2 according to the similar analysis with the currentless assumption. When we take the net toroidal current into account, the achieved pressure gradient approaches to the low-n ideal MHD stability boundary. Then the low-n ideal MHD boundary looks to still limit an operational regime of the pressure gradient at the core region in 3.5m configuration. However, the low-n instability condition seems to be relaxed comparing with 3.6m configuration.

As regards the achieved pressure gradient at ρ=0.9, which is close to the ι=1 rational surface. The data is in the beginning of the unstable region, which is similar with 3.6m configuration.

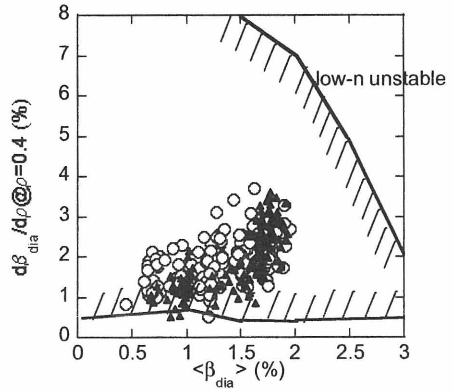

Fig.1 Achieved pressure gradient at ρ=0.4 (ι~1/2) in Rax=3.5m configuration with β-dβ/dρ diagram.

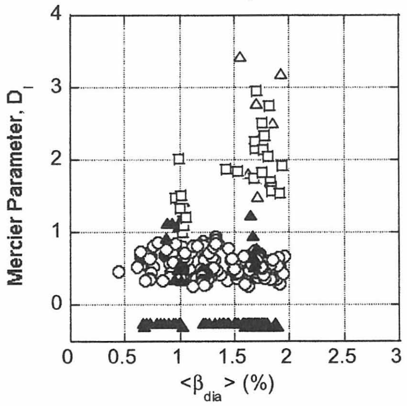

Fig.2 Dependence of Mercier parameter on beta at ι~1/2 in Rax=3.5m configuration.

[1] S. Sakakibara et al, Nuclear Fusion **41**(2001)1177.