§3. Linear Stability Analysis of Ideal Ballooning Modes in SDC-IDB LHD Plasmas

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SDC-IDB plasmas in the LHD experiments [1] are characterized by the high values of core density with the internal diffusion barrier. For these SDC-IDB LHD plasmas, the linear stability analysis is done by using the ideal high-n ballooning code [2].

We consider four density profiles with different core density shown in Fig.1. The temperature is fixed to $T/T(0)=1-\rho^4$ with T(0)=0.8keV. B_0=2.75T is assumed. These are used to calculate the MHD equilibrium by the VMEC [3]. The outer most flux surfaces with vacuum magnetic axes, R_0=3.60m, 3.75m, and 3.90m are considered, which are taken from the LHD data base.

The typical results are shown in Fig.2. For all cases, it can be confirmed that the ballooning unstable region laps over the Mercier unstable region, except for the case of R_0=3.90m with β_0~4%. The modes are thus interchange-like modes, which can also be confirmed by its extended structure along the field line. The interchange modes can be well explained by the magnetic well/hill, and as is well known, the magnetic hill is improved as the axis goes outside in the LHD configurations. The growth rates are thus reduced from inward to outward configurations.

We consider the phase just after the pellets. In that time, the density profile is broad with the high core density. After that, the core density is kept high while the edge density is reduced. This temporal change of the density will correspond to our profiles 4 => 1 (Actually the profile 2 is best fitted to the experimental profiles). In the cases of R_0=3.75m and R_0=3.90m configurations for profile 4, the outer region is slightly unstable. Thus this is not inconsistent with the reduction of the edge density. However, when the profile becomes more peaked, for example, profile 3, it is stabilized. The profile 3 is not similar to the usual SDC with IDB. When the beta becomes higher, the instabilities in the edge region will be more unstable. However, our assumed beta values seem to cover the experimental situations well.

For the peaked profiles; 1 and 2 profiles, it is found difficult to obtain higher beta MHD equilibrium by the VMEC with high accuracy. This suggests that the MHD force balance is hard to satisfy. It is unknown why such steep density gradient is kept with bad transport region in the edge. In conclusion, it is difficult to simply relate our ideal MHD ballooning results to the formation of SDC with IDB.

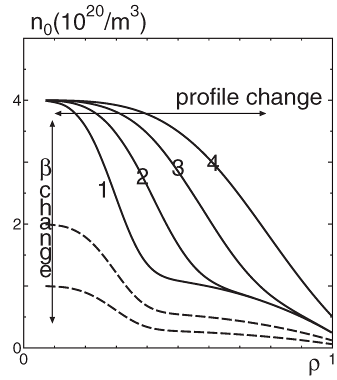

Figure 1: Assumed density profiles.

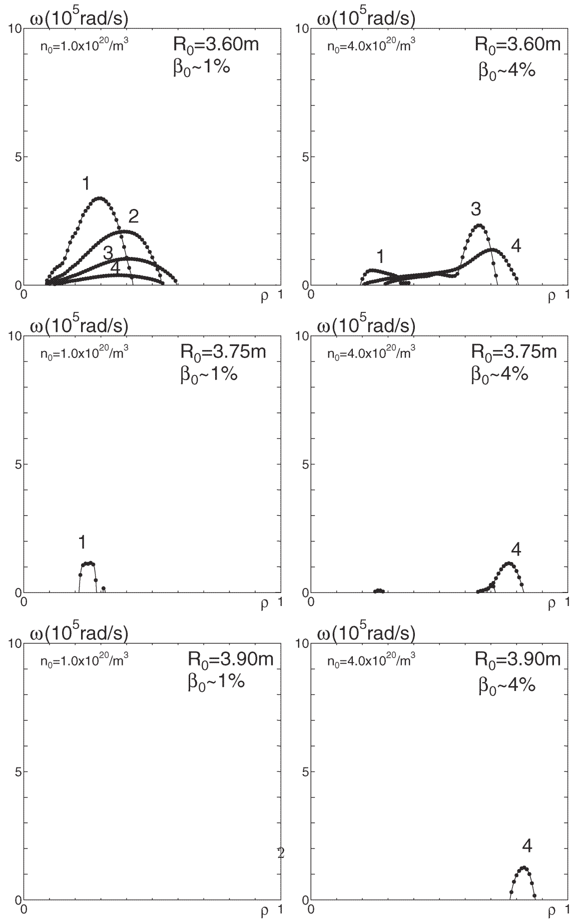

Figure 2: Ballooning growth rate as a function of ρ in R_0=3.60m (top), R_0=3.75m (mid) and R_0=3.90m (bottom) configurations of LHD. Left (right) column corresponds to the 1% (4%) central beta cases.

1) N.Ohyabu et al., Phys. Rev. Lett. **97**, 055002 (2006)
2) O.Yamagishi et al., Phys. Plasmas **8** 2750 (2001)
3) S.P.Hirshman, Phys. Fluids **26**, 3553 (1983)