# §3. The 2nd Stability of Ballooning Modes in the Inward-shifted LHD Configurations

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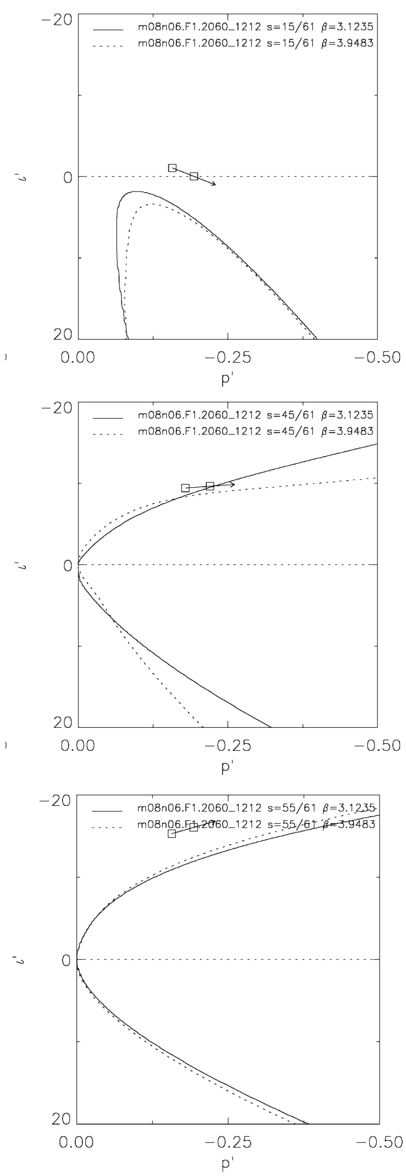
MHD stability analyses of high-$\beta$ equilibria in the inward-shifted LHD configurations are performed [1], by using the currentless free boundary equilibria with pressure profile $P(s) = P(0)(1-s)(1-s^9)$ where $s$ is the normalized toroidal flux. The conditions for the MHD equilibria, namely the free boundary condition, the currentless condition, and the chosen pressure profile, reflect the experimental observations. The key points are that Mercier criterion is significantly improved by the magnetic well formation and that the dangerous $\iota = 1/2$ rational surface disappears, as $\beta$ increases. Those improvements are brought by the Shafranov shift of the whole plasma, leading to strong stabilization (self-stabilization) as $\beta$ increases. In order to examine this situation in detail, the method of the equilibrium profile variations [2, 3] has been applied to the MHD equilibria. This method of equilibrium profile variation is a very powerful means to investigate the stability margin of the equilibrium against high-mode-number ballooning modes, and gives the $d\iota/d\psi - dP/d\psi$ stability diagram corresponding to the $s - \alpha$ diagram in tokamaks. Typical examples are shown in Fig.1, where $d\iota/d\psi - dP/d\psi$ stability diagram in the plasma core (first row), in the plasma periphery (second row), and in the plasma edge (third row) is drawn. The horizontal and vertical axes correspond to $-s_q$ and $\alpha$ in the $s_q - \alpha$ diagram of tokamak plasmas. The solid (dashed) curves indicate the stability boundary of high-mode-number ballooning modes for $\beta = 3\%$ ($\beta = 4\%$). Two squares attached to the arrow in each graph indicate the positions of $(\iota', P')$ corresponding MHD equilibria at $\beta = 3\%$ and $\beta = 4\%$. The arrows denote the direction of the shift of $(\iota', P')$ corresponding the MHD equilibrium as $\beta$ increase from $\beta = 3\%$ to $\beta = 4\%$. Judging from the direction of shift of MHD equilibrium according to $\beta$ value and the relative position of MHD equilibria to the stability boundary, it might be concluded that the core region stays in the second stability state, the peripheral region stays near the marginally stable state, and the edge region stays in the first stability state. Note that the pressure profiles used here have been experimentally obtained by using the gas puffing, so that the pressure gradient in the plasma periphery, where the high-mode-number ballooning modes are near the marginally stable state, is fairly stronger than that obtained by using pellet injection.

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[2] C. C. HEGNA and N. NAKAJIMA, Physc. Plasmas **5** 1336 (1998).
[3] S. R. HUDSON and C. C. Hegna, Physc. Plasmas **10** 4716 (2003).