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Characteristics of MHD Instabilities Limiting Beta Value in LHD

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Effects of low-n MHD instabilities on plasma performance have been assessed in the regime where an achieved beta value is regulated by instabilities. In stellarators and heliotrons, interchange instability driven by pressure gradient is most concerned to impose the limit of the achievable beta value. Previous experiments in LHD show that high beta plasma with more than 5 % was successfully achieved in the moderately unstable regime where violated instabilities are benign and does not result in harmful consequence like disruption. The resistive interchange modes were dominantly observed in the all beta range because of magnetic hill in periphery, and it was verified that the amplitudes of modes were suppressed by an increment of the magnetic Reynolds number, S, which is favorable in fusion reactor regime with high electron temperature, Te. However, since the growth rate of the ideal interchange mode is independent of S, verification of the significance of the ideal stability boundary is still major problem to be solved in helical devices. Here we focus on the effect of the mode on the confinement property in the regime where the destabilization of the ideal interchange mode is predicted by linear theory. The unstable regime of an ideal interchange mode is characterized by enhanced magnetic hill and reduced magnetic shear. The magnetic hill was enhanced by shifting the magnetic axis position to the inward, whereas the magnetic shear was reduced by increasing the plasma aspect ratio and/or plasma current. In the enhanced magnetic hill configuration, the rotating m/n = 2/1 mode appears and the amplitude is increased with deceleration of the mode rotation, which forms the flattening structure of pressure profile around the m/n = 2/1 resonance. After the stop of the rotation, the profile flattening is extended to the core region, which drops the central beta by more than 30 %. In the reduced magnetic shear configuration, m/n = 1/1 mode also decreases the central beta by about 60 % after the stop of the rotation as well as m/n = 2/1 mode. Both experiments give us the following key results: (i) low-n modes are significantly destabilized in the ideal-unstable configurations and lead to degradation of central beta by at most 60 %, and (ii) the degree of their damages strongly depends on the mode rotation velocity.

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