Effects of three-dimensional magnetic field structure to MHD equilibrium and stability

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The stellarator and heliotron are other candidates to magnetically confined fusion device. Major difference is the production of the rotational transform ι=1/q. In tokamaks, the rotational transform ι is produced by coupling symmetric toroidal field and the plasma current along toroidal direction. Strictly speaking, the tokamak configuration can be assumed to the two-dimensional (2D) system. Note that the rotational transform does not exist for the vacuum. For stellarator and heliotron configurations, the rotational transform is produced by shaping of flux surfaces. To shape flux surfaces, the magnetic field for the vacuum is produced by external coils with helical-winding laws. This means the magnetic field produced for the vacuum is intrinsically the three-dimensional (3D) system. Then, the plasma current to make flux surfaces is not necessary. This nature leads to the advantage. Since the plasma current is not necessary, the disruption does not appear and the steady-state operation is possible. However, appearing 3D plasma responses, experimental and theoretical studies are sophisticated.

In this talk, we show some topics about the magnetohydrodynamics (MHD) equilibrium and stability studies in the Large Helical Device (LHD). The LHD is an L=2/M=10 heliotron configuration. The first topic is the MHD equilibrium study. In the 3D system, the MHD equilibrium equations cannot be solved uniquely. The identification of the MHD equilibrium is an important problem. In addition, coupling the 3D plasma response nonlinearly, natural islands and stochastizations appear. In the experiment, the volume averaged beta value $<\beta>$ achieved to 5% and the discharge can be sustained steadily longer than 100 τ_E. We discuss the 3D plasma response to the MHD equilibrium taking high-β plasmas as examples. As the next topic, we show experimental and theoretical studies of the MHD instability in the LHD. If the pressure profile becomes steep in the plasma core, major collapse, which is so-called the Core Density Collapse (CDC), appeared. A speculation driving the CDC is proposed from a nonlinear dissipative MHD simulation. We show results of the simulation and comparison to experimental observations. The third topic is interactions between the pressure driven instability and resonant magnetic perturbation (RMP) field. Superposing low-n RMP fields, properties of instabilities were changed. As the final topic, we show the heat transport on the stochastic field driven by the MHD instability. The heat transport strongly depends on the magnetic field structure.