§1. Reproduction of Mode Rotation in LHD by Numerical Simulation

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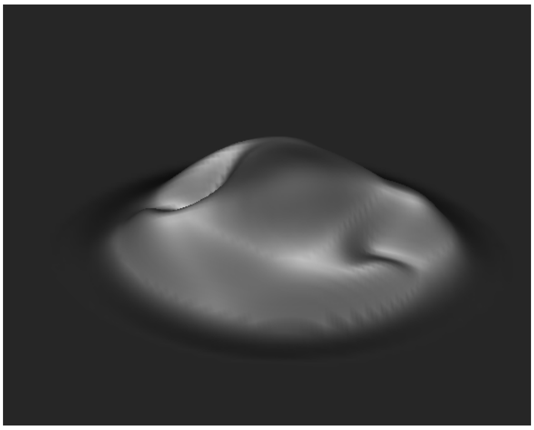
The effects of shear flow on the magnetohydrodynamics (MHD) property of the LHD plasmas are studied by using three-dimensional numerical codes. In the experiments, the mode rotation is ordinary phenomena in the observation, and the rotation is often utilized for the identification of the mode numbers of MHD phenomena. In this case, it is assumed that the plasma is in the saturation phase of MHD modes and the global structure is rotated in the poloidal and toroidal directions. However, in the numerical analysis of the MHD phenomena in the LHD, such rotation of the global structure has not been explicitly analyzed. Thus, in this research, we carry out the numerical simulation of an LHD plasma incorporating the plasma flow and we reproduce the mode rotation [1].

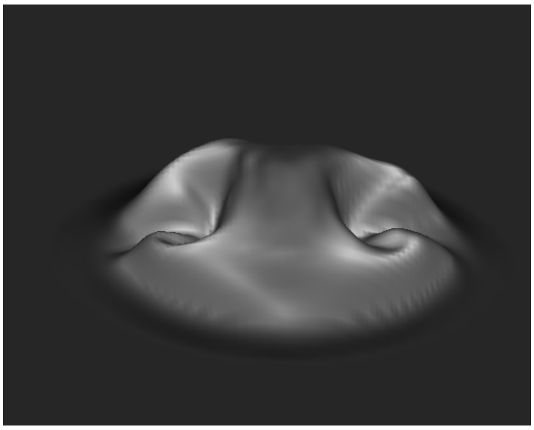
At first, we calculate a static equilibrium, and then we follow the time evolution of the MHD dynamics. In the dynamics calculation, we incorporate a finite poloidal flow in the initial condition. The HINT code [2] and the MIPS code [3] are utilized in the equilibrium and the dynamics calculations, respectively. In order to analyze the change of the global structure, we utilize a configuration that is unstable against the interchange mode. We employ the parabolic profile of $P = P_0(1-\rho^2)(1-\rho^8)$ for the equilibrium pressure and the axis beta of $\beta_0 = 4.4\%$, where ρ denotes the normalized square root of toroidal magnetic flux. The profile of the flow is chosen to be close to an experimental data.

In this equilibrium, the interchange mode grows linearly and saturated nonlinearly. The mode generate local vortices around the resonant surface so as to generate high and low pressure regions. In the saturation phase, the structure corresponding to the mode numbers appears in the pressure profile. In the case of finite flow of which the kinetic energy is similar to the saturation level of the no flow case, the $m = 2/n = 2$ structure generation is observed. Figure 1 shows the time evolution of the bird's eye view of the pressure profile in the horizontally elongated cross section. When we focus on the phase change of the high pressure region we can recognize the rotation of the structure. In the simulation without the flow, such rotation were not observed. That is, the rotation of the global mode due to the poloidal plasma flow is reproduced. We will advance such analysis so as to observe the rotation for longer time and compare with the experimental data more precisely in future.

(a)



(b)



(c)

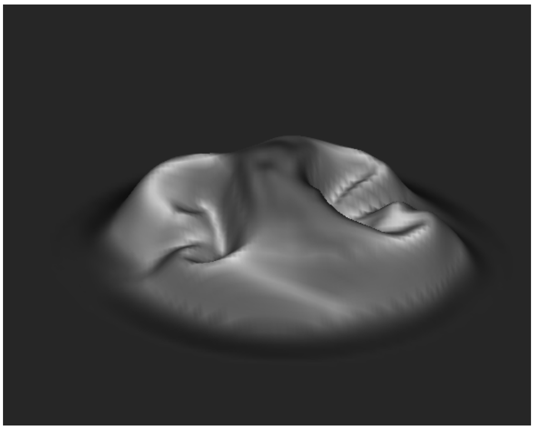


Fig.1. Time evolution of total pressure for $V_\theta/V_A = 10^{-2}$ at $t =$ (a) $420\tau_A$, (b) $440\tau_A$ and (c) $460\tau_A$.

[1] K. Ichiguchi, et al., 20th International Stellarator/Heliotron Workshop, 5-9 Oct. 2015, Greifsvaldt, Germany.
[2] Y. Suzuki, et al, Nucl. Fusion **46** (2006) L19.
[3] Y. Todo, et al, Plasma and Fusion Res. **5** (2010) S2062.