§1. Effects of the Stochasticity on Transport Properties in High-β LHD

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Generating and keeping clear flux surfaces are an aim of magnetic confinement researches, because the stochasticity of magnetic field lines leads the degradation of the confinement connecting between core and edge region. There are some analytical works investigating the impact of the stochasticity of magnetic field lines on the radial transport property[1)2)3)4)]. In those works, Rechester and Rosenbluth pointed out the radial heat diffusivity due to stochastic field lines relates to both the stochastic diffusion parallel and perpendicular to the magnetic field[1)]. The stochasticity of field lines due to finite-β effects is an intrinsic property in stellarator/heliotron. Since the pressure-induced perturbed field breaks the symmetry of the field, the structure of magnetic field lines becomes stochastic, especially in the peripheral region. In order to aim stellarator/heliotron reactors, the study of the transport due to stochastic field lines is a critical and urgent issue. In this study, we study high-β MHD equilibria in LHD and estimate the stochasticity of the magnetic field quantitatively.

Figure 1 shows a puncture map of magnetic field lines of an inward shifted configuration, R_{ax}=3.6m, γ=1.254, BQ=100%. The equilibrium is calculated by HINT2[5)], which is a 3D MHD equilibrium calculation code without the assumption of nested flux surfaces. The initial pressure distribution is set to $p = p_0(1 - s)(1 - s^4)$. The peak beta value β_0 is about 7% and the volume averaged beta value <β> is about 3.3%. A green line is the profile of normalized plasma pressure at the axis. Two arrows indicate positions of the last closed flux surface (LCFS) for the vacuum. The axis shifts toward the outside of the torus. Field lines in the peripheral region become strongly stochastic and the LCFS shrinks to the plasma core. However, the finite pressure gradient exists in the stochastic region. Figure 2 shows detailed puncture map, profiles of the normalized pressure P/P_0 and connection length L_C corresponding to puncture map, profiles of diffusion coefficients of magnetic field lines and the inverse of the Kolomgrov length. Despite of becoming field lines stochastically, the pressure gradient keeps in the region with long L_C. This suggests a possibility stochastic field lines with long L_C can sustain the plasma pressure. On the other hand, D_{FL} and L_k increase in the stochastic region. However, D_{FL} increases smoothly but L_k jumps the boundary between the LCFS and the stochastic region. This suggests the correlation length of the stochasticity along the parallel direction is further important. Comparison of the heat diffusivity between the experiment and the analytical estimation is next subject.

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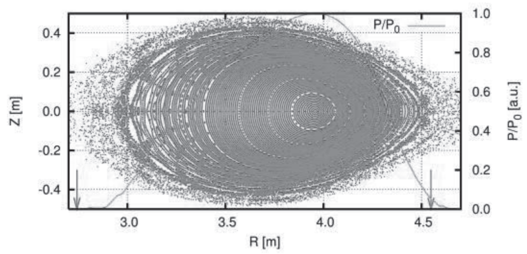

Fig.1. Puncture map of field lines of an inward shifted configuration. The profile of the normalized pressure at the axis is also shown. Two arrows indicates positions of the LCFS for the vacuum.

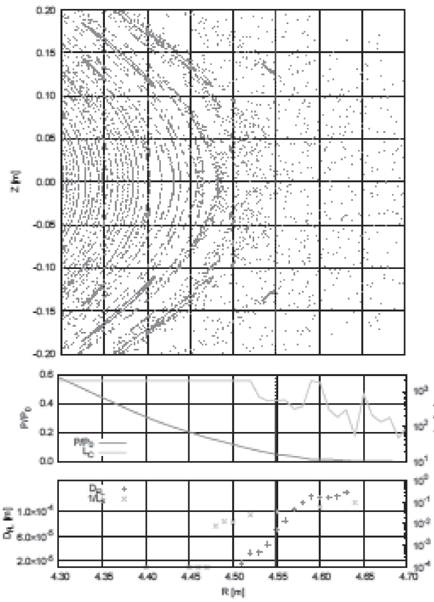

Fig.2. Detailed puncture map of field lines and profiles of the plasma pressure, connection length of field lines, the diffusion coefficient D_{FL} and the inverse of the Kolmogrov length L_k are shown.