Turbulence Diagnostic Simulator - measurement of magnetic island

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Self-regulated structure formation in high-temperature magnetized plasmas, such as transport barriers and magnetic islands, has been crucial for the confinement performance and the stability of fusion plasmas. Progress in the high-resolution spatiotemporal measurement allows us to obtain experimental data including detailed spatial profiles and dynamic changes of perturbed plasma fields[1]. In order to understand the physical process of structure formation, an analysis technique for the interpretation of experimental data should be developed. To this aim, we have been developing a turbulence diagnostic simulator, in which the dynamics of torus plasma is numerically simulated, and the simulation data is analyzed as the same method in the experiment. This idea is based on the previous achievement made by the direct comparison between the numerical simulation[2] and the experimental observation[3] in laboratory plasmas. In the present study, as an example, magnetic island in large helical device (LHD) is simulated, and the numerical diagnostic is performed. The property of magnetic island in LHD is the following. LHD have a set of external current coils, which produces (m,n)=(1,1) resonant magnetic perturbation (m and n are poloidal and toroidal mode numbers). Even when the tearing mode is stable, the sufficiently strong magnetic perturbation destabilizes the tearing mode and magnetic island appears at the corresponding resonant surface[4]. It has been observed that such a magnetic island flattens pressure gradient and perturbs electric field (E×B flow) in the vicinity of magnetic island[5].

A reduced set of two-fluid equations is numerically solved in a cylindrical plasma to simulate the nonlinear dynamics of magnetic island. An effect of resonant magnetic perturbation is included by imposing the finite edge boundary condition on the perturbed vector potential corresponding to magnetic island. In the present status of the model, the effect of curvature of magnetic field line is not taken into account yet, and there does not exist the drift-interchange type turbulence. When magnetic island grows up, pressure and electric field profile are perturbed by the magnetic island. In the next step, the plasma fields are measured. Microwave interferometer and heavy ion beam probe are considered to measure profiles of perturbed pressure and electric field. For simplicity, microwave and heavy ion are considered to be passive. Spatiotemporal measurement accuracy due to detector performance is taken into account, and an error in the measurement is estimated. Meso-scale structures of perturbed pressure and electric field in the vicinity of magnetic island are analyzed, and the interaction between magnetic island and these fields is discussed.

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