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Transport Analysis of Oscillatory Phenomena for Plasma Dynamics in Helical Plasmas
ヘリカルプラズマでのプラズマダイナミクスにおける振動現象に関する輸送解析

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The formation mechanism of transport barriers is important issue to realize improved confinement modes in toroidal plasmas. One possible mechanism to explain the transport barriers is the spatial transition in the profile of the radial electric field E_r and the suppression of turbulence by its shear. In the nonaxisymmetric system, the radial electric field is determined by the ambipolar condition. In tokamaks, the model of L/H transition and the edge localized modes (ELMs) which is based on the bifurcation of the radial electric field was presented. In helical plasmas, two kinds of the oscillation for the plasma quantities are experimentally observed. Firstly, the limit cycle phenomena in the temporal evolution of the electrostatic potential, namely the electric pulsation, have been observed in the core region. Related with the electric pulsation, the electron internal transport barrier is observed in the electron temperature profile. Therefore, the physical mechanism, which realizes the oscillatory plasma state, is critical for the study of improved confinement modes. In our recent work, temporally oscillating solutions of the radial electric field are obtained. Secondly, the density limit oscillation in the W7-AS experiments [1] was reported. The achievable limit of the density due to the radiation collapse has been studied, because the strong degradation of the confinement occurs if the radiation collapse happens. Dynamics of the radial structure for the plasma quantities are important for the study of the density limit. The zero-dimensional dynamical model was shown for the oscillation of the density near the density limit. The oscillatory state for the plasma dynamics has not been obtained yet by use of a one-dimensional transport analysis, which includes the radiative loss.

To theoretically predict the electric pulsation in the core region of helical plasmas, the transport model for LHD-like plasmas is constituted by the one-dimensional diffusion equations of the density, the electron and ion temperatures, and the radial electric field. A neoclassical transport database DCOM/NNW for LHD (DGN/LHD) has been constructed [2]. In order to estimate the neoclassical transport and the ambipolar radial electric field for LHD in details, the DGN/LHD for the nonaxisymmetric part of the radial flux is adopted in the diffusive equations. The DGN/LHD is used for the simulation to reproduce the electric pulsation in the core region and to predict the parameter region for the electric pulsation in the LHD experimental results. The dependence of the transition point for the radial electric field on the particle source is studied. The variation of the solution type (the stationary or oscillatory state) is also examined.

To examine the density limit oscillation in helical plasmas, we add the term of the radiative loss due to the impurity ions to the temporal equation for the electron temperature. The temporal evolution of the density profile is newly included in the transport model equations. The result for two states, which are dominated by the transport or the radiation, is shown. Dynamics of the plasma quantity is studied and the temporal transition from the transport-dominated state to the radiation-dominated state is examined.

[1] L. Giannone, et al., Plasma Phys. Control. Fusion **42** (2000) 603
[2] A. Wakasa, et al., J. J. Appl. Phys. **46** (2007) 1157