§1. Hierarchy-renormalized Simulation Model

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In order to develop a predictive simulation code system in 3D toroidal magnetic configuration like LHD, a hierarchy-renormalized simulation model is proposed under domestic and international collaborations with universities and institutes.

The hierarchy-renormalized simulation model consists of a hierarchy-integrated simulation approach and a hierarchy-extended simulation approach.

The hierarchy-integrated simulation approach, which is mainly based on a transport simulation combining various simplified models describing physical processes in different hierarchies, is suitable for investigating whole temporal behavior of experimentally observed macroscopic physics quantities. The hierarchy-integrated simulation code is being developed based on the integrated modeling code for tokamak plasmas; TASK, developed in Kyoto University, and is called TASK3D.

The hierarchy-extended simulation approach, which includes core plasma fluid description, core plasma kinetic description, and peripheral plasma fluid/kinetic description, is focused on the description of mutual interaction among neighboring hierarchies in a more rigorous way. In core plasma fluid description, MHD nonlinear dynamics is investigated by using MINOS code with high accuracy, interaction between high-energy particles and background MHD modes is examined by using MEGA code consisting of the drift-kinetic energetic particles and background MHD fluid, multiple-phase states consisting of gas, liquid, and solid phases related to the ablation of a solid pellet are analyzed by using CAP code, and interactions among microscopic turbulence, macroscopic MHD modes, and meso- scale zonal flows is examined by using RTF5 based on a two-fluid simulation model. In the core plasma kinetic description, various types of gyro-kinetic Vlasov code; GKV is developed and used for performing ITG and ETG linear and nonlinear local analyses in both two- and three-dimensional toroidal magnetic configurations.

The hierarchy-renormalized simulation model is constructed by renormalizing the results of the hierarchy-extended simulation model, as a comprehensive theoretical model, or numerical data, or module into the hierarchy-integrated simulation code.

In a short term, predictive simulations based on the hierarchy-integrated simulation model; TASK3D will be performed for the deuterium experiments being planned in LHD; while, in a long term, the hierarchy-renormalized simulation research will be done, leading to the LHD Numerical Test Reactor.