§42. Hierarchy-integrated Simulation Code; TASK/3D

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In order to develop a predictive simulation code system in three-dimensional toroidal magnetic configuration like LHD, a hierarchy- renormalized simulation model is being proposed under domestic and international collaborations with universities and institutes. The hierarchy- renormalized simulation model in three- dimensional toroidal magnetic configurations consists of a hierarchy-integrated simulation approach and a hierarchy-extended simulation approach. The hierarchy-extended simulation approach, which includes fluid core plasma description, kinetic core plasma description, and peripheral fluid/kinetic description, is focused on the description of mutual interaction among neighboring hierarchies in a more rigorous way.

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 such as densities and temperatures of both electrons and ions. The hierarchy-integrated simulation code is now being developed based on the integrated modeling code for tokamak plasmas; TASK [1], developed in Kyoto University, and is called TASK/3D. The TASK consists of several modules, namely, a two-dimensional equilibrium module (EQ), a one-dimensional transport module (TR), a local dispersion relation module (DP), a ray/beam tracing wave analysis module (WR), a full wave analysis module (WM), a three-dimensional Fokker-Planck module (FP), a data connection module (PL), a matrix solver module (MTX), and a common library (LIB). TASK is equipped with various external particle and heat sources. TASK is also parallelized in terms of MPI. In order to extend the TASK code developed for two-dimensional magnetic configurations to three-dimensional ones as TASK/3D, TASK is being rewritten in Fortran 95 from Fortran 77, the modular structure is being so fairly rearranged that the interface becomes suitable to both two and three dimensional configurations, and the transport equations for the rotational transform and the radial electric field have been reformulated in general three-dimensional toroidal configurations. With this new formulation, temporal evolution of the net current in LHD has been analyzed [2,3]. The first generation of the hierarchy-integrated simulation code; TASK/3D will be created with introducing the temporal evolutions of both the rotational transform and the radial electric field.

In a short term, predictive simulations based on the hierarchy-integrated simulation model; TASK/3D will be performed for the deuterium experiments being planned in LHD; while, in a long term, the hierarchy-renormalized simulation research will be done 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 model, leading to the LHD Numerical Test Reactor.

[1] A. Fukuyama et al., Proc. of 20th IAEA Fusion Energy Conf. (Villamoura, Portugal, 2004) IAEA-CSP-25/CD/TH/P2-3.

[2] Y. Nakamura et al., Fusion Sci. and Tech. 50 (2006) pp.457-463.

[3] Y.Nakamura et al., Proc. of 21th IAEA Fusion Energy Conf. (Chengdu, China, 2006) IAEA-CN-149/TH/P7-1.