§15. Module Structure of Hierarchy-integrated Simulation Code for Toroidal Helical Plasmas, TASK3D

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The hierarchy-integrated simulation code for toroidal helical plasmas, TASK3D, is being developed based on the TASK (Transport Analyzing System for tokamaK) [1] for two dimensional configurations. The TASK3D has a module structure, allowing us to carry out simulations by using an individual module or combination of some modules for the user's purpose. For the extension of the TASK to the TASK3D for three dimensional configurations, implementation of new modules (reflecting three-dimensionality of configurations) into the TASK has been progressed as shown in Fig.1 (as indicated by italics). At the current stage of the development of the TASK3D, the extension of the TR module is main topic. In the TR module, the particle and heat transport equations are solved. The original TR module in the TASK also solves the equation of the magnetic field for analyzing the plasma current. However, the equation of the magnetic field is derived by assuming the axisymmetry of configurations so that it cannot be applied for analyzing the plasma current in helical plasmas. Therefore, the equation for the rotational transform in general toroidal configurations has been reformulated and the new module (EI module) was developed and tested[2]. Calculations on temporal evolution of the rotational transform and the non-inductive current for an LHD experiment already have been performed [2,3]. In such simulations, the stand-alone rotational transform/plasma current module (EI module) was utilized together with the VMEC/BSC (MHD equilibrium consistent with the plasma current) module(cf., Fig.1).

Another important extension of the TR module for helical plasmas is to take into account of the effect of radial electric field E_r since the ambipolar condition is not satisfied intrinsically due to the non-axisymmetry of helical plasmas, and E_r is determined by the neoclassical transport. The time scale of the time evolution of E_r is much faster than for the density and the temperature. At the current stage of development of the TASK3D, the ER module has been developed and implemented to the TASK3D, where E_r is determined from the ambipolar condition by assuming the stationary state of the equation of time evolution of E_r in order to avoid the problem of the different time scale. This implementation is the important step of the development so that the E_r bifurcation nature of helical plasmas can be now treated in the simulation. The two options for neoclassical flux calculations have been implemented, one is based on the analytical formulae[4] and the other is on the neoclassical diffusion coefficient database being constructed by the DCOM/NNW (Diffusion Coefficient Calculator by Monte Carlo Method / Neural NetWork) [5].

In the next step of the development of the TASK3D, we will implement the EI module, so that the fully inter-linked time evolutionary simulations for the rotational transform/plasma current become possible. By doing this implementation, we will become able to calculate the time evolution of temperature, density, E_r and rotational transform, simultaneously. In addition, the currently used stationary ambipolar condition for determining E_r will be replaced by the equation of time evolution of E_r. Impurity module and heating modules will also be added to TASK3D for further development of the hierarchy-integrated simulation code for toroidal helical plasmas.

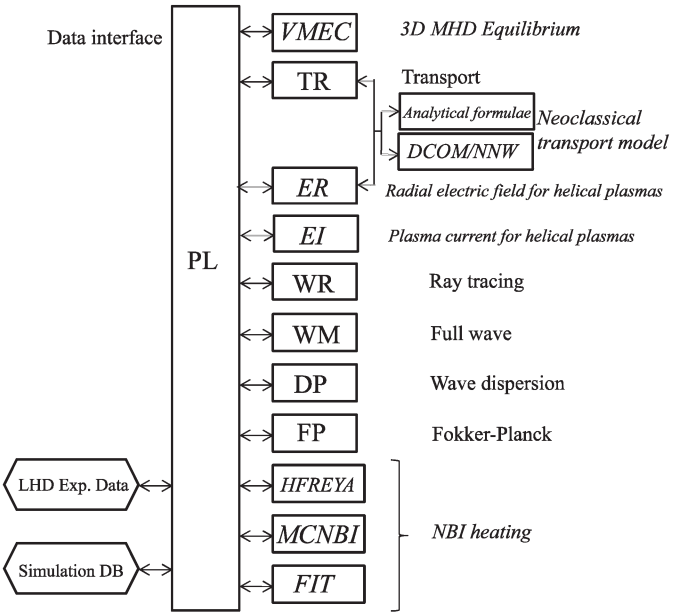

Fig. 1. Module structure of TASK3D. Modules denoted by italics have been developed/implemented.

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