§82. Development of Integrated Simulation Code for LHD Plasma Experiments

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Recent progress of computers (parallel/ vector-parallel computers, PC clusters, for example) and numerical codes for helical plasmas like three-dimensional MHD equilibrium codes, combined with the development of the plasma diagnostics technique, enable us to do the detailed theoretical analyses of the individual experimental observations. There are a lot of experimental data analyses using an individual numerical analysis code and many excellent results have been obtained for the LHD experiments. Now, it is pointed out that the experimental data analysis from the viewpoints of integrated physics, such as transport, heating, MHD equilibrium/stability, is an important issue to understand the confinement physics globally. To do that, the development of the integrated simulation system which has a modular structure and user-friendly interfaces is necessary. The integrated numerical simulation will also be a good help to draw up new experimental plans. In this study, we have started the development of such a system.

The integrated simulation system to be developed has a modular structure which consists of modules for calculating MHD equilibrium/stability, transport and heating. Each module can be selected in accordance with a user's request and can be combined with other modules. In order to maintain the independence of each module, which is an independent and complete program, sequences of the integrated simulation are controlled by a shell or script (perl or ruby, for example). Since some modules are suitable for running on the vector machine and others are on the PC cluster, we are going to develop a module-by-module distributed computing system through the network.

When we want to perform the integrated simulation during the entire plasma duration, a transport module is to be a core module. An integrated tokamak transport code, TASK[1], which is a core code for BPSI (Burning Plasma Simulation Initiative; research collaboration among universities, NIFS and JAERI in Japan) activity, will be extended for the helical configuration and used as a transport module. Figure 1 shows the schematic of a module structure of the integrated simulation system presently considered.

This fiscal year, we have reviewed the modeling and the specifications of interfaces between modules, and developed MHD equilibrium code HINT2 and bootstrap current calculation code BSC. The HINT2 is a revised code of the HINT and coded using Fortran 90. It is used for calculating accurate MHD equilibrium of LHD including peripheral ergodic region.

Though almost all transport simulations done for LHD plasmas have neglected the net toroidal current, finite net plasma current has been observed in actual LHD experiments. It is considered that the bootstrap current and the beam driven current are included in it, but it is difficult to estimate fraction of these components accurately because plasmas are not stationary in many cases. So, as the first step of the extension of the TASK, time evolution of the plasma net current, which is consistent with the three-dimensional MHD equilibrium (by VMEC), will be solved for LHD plasmas by using time evolution of density and temperature profiles obtained by the experiment and taking into account of the bootstrap current and the beam-driven current. In order to calculate the bootstrap current, we have developed the BSC code, which is suitable for the usage as a module, by improving SPBSC code. The BSC code has been applied to the analysis of the bootstrap current observed in Heliotron J plasmas. It is shown that the neoclassical transport theory can explain the experimental observation that the bumpy field component can change the direction of the bootstrap current.

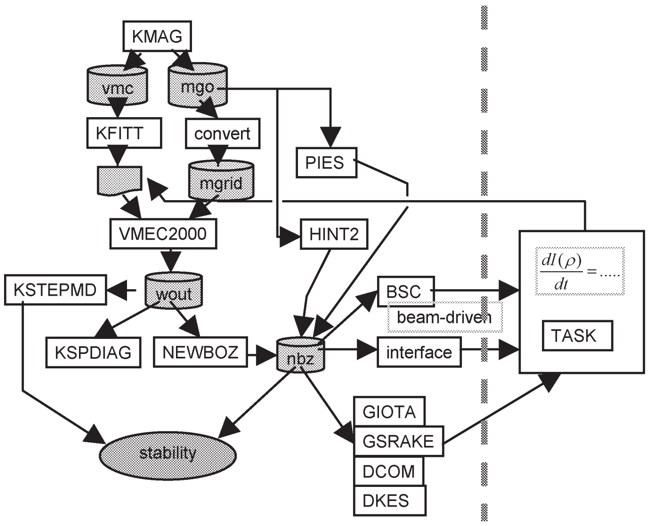

Fig.1 Schematic of the module structure of the integrated simulation system

Reference

1) A. Fukuyama, S. Murakami, M. Honda, Y. Izumi, M. Yagi, N. Nakajima, Y. Nakamura, T. Ozeki, Proc. of 20th IAEA Fusion Energy Conf., IAEA-CSP-25/TH/P2-3 (Vilamoura, Portugal, Nov. 1-6, 2004)