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Integrated Simulation of Reactor Plasma at IFERC-CSC
IFERC-CSC における炉心プラズマ統合シミュレーション

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In order to predict the behavior of burning plasmas, the role of integrated simulation describing whole plasma and whole discharge is becoming more important. There are various levels of modeling for equilibrium, transport, global stability, source, and so on. Advanced modeling often requires a large amount of computer resources which will be available at BA-IFERC-CSC. Kinetic integrated modeling based on momentum distribution function is such an example. Parameter survey and optimization with medium-size integrated simulation will be also carried out at CSC. For the final goal of integrated modeling, development of reliable reactor plasma simulator with various levels of modeling, the computer resources at CSC has to be utilized most effectively.

1. Introduction

In order to predict the behavior of burning plasmas, examine the operating scenario, and support the design of demo reactors, integrated modeling of fusion reactor plasmas is indispensable. For this purpose the integrated modeling code should describe whole plasmas (core, edge, peripheral, and divertor plasmas as well as wall plasma interaction) and whole discharges (start up, sustainment, probabilistic event, and shut down). Since the time scales of the phenomena involved are desperately separated and so do the spatial scales, it is impossible for a single physics model to describe all phenomena. Therefore integrated modeling in which various physics models are coupled with each other self-consistently is required.

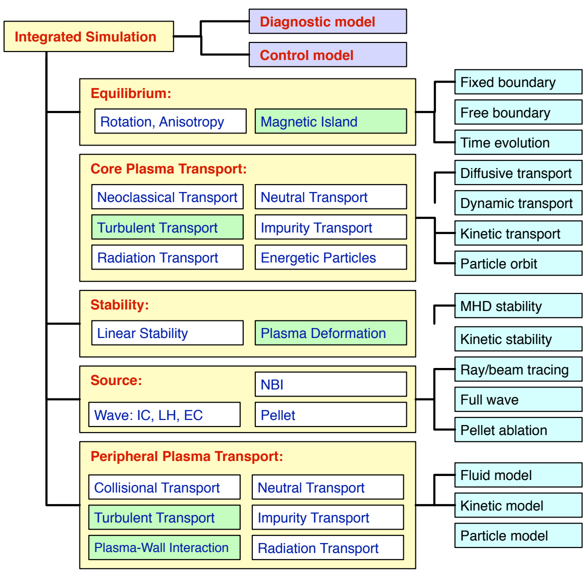

Fig. 1. Typical structure of integrated modeling

Fig. 1 indicates typical structure of integrated modeling. Some of reduced models are derived from the results of large-scale nonlinear simulation such as turbulent transport and nonlinear MHD interactions.

2. Various levels of modeling

There are various levels of modeling for the phenomena in reactor plasmas. For example, the analysis of MHD equilibrium which determines the shape of plasma becomes complicated when toroidal and poloidal flows, anisotropic pressure, and finite gyro radius effects are included. Non-axisymmetric effects of course require qualitatively-different advanced analysis. Example of level of transport modeling is shown in Fig. 2. The level of modeling to be used depends on the purpose of analysis, required accuracy, expected turn around time, and available computer resources. Therefore future integrated simulation codes should include various levels of modeling for equilibrium, transport, global stability, source, and so on.

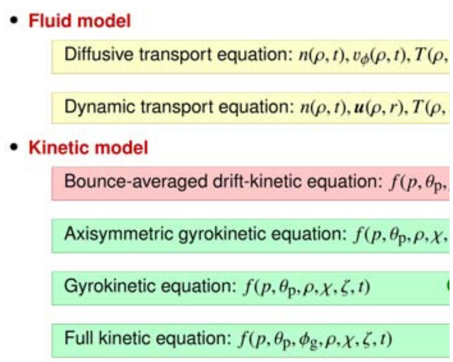

Fig. 2. Levels of transport modeling

3. Integrated simulation to be carried out at CSC

To make the most use of the computer resources at the BA-IFERC-CSC, integrated simulations which require large resources and have been optimized for parallel processing are desired. We are developing the kinetic integrated modeling code, TASK-3G, based on the integrated modeling code TASK shown in Fig. 3. In TASK-3G, the status of plasma is represented by the bounce-averaged velocity distribution functions, two-dimensional in velocity space and one-dimensional in radial direction, for plasma species. Their time evolution is described by a Fokker-Planck type bounce-averaged drift kinetic equation. Modification of velocity distribution functions due to heating, current drive, fusion reaction, and radial diffusion affects the fusion reaction rate, current drive efficiency, and global stabilities. Fig. 4 illustrates the effects of momentum dependence of radial diffusion coefficient on the formation of energetic ions. The Fokker-Planck equation solver and the full wave solver for global stability analysis have been parallelized. Such an advanced integrated simulation will be suitable for CSC.

Another possible usage of CSC will be a parameter survey and optimization using medium scale integrated simulation.

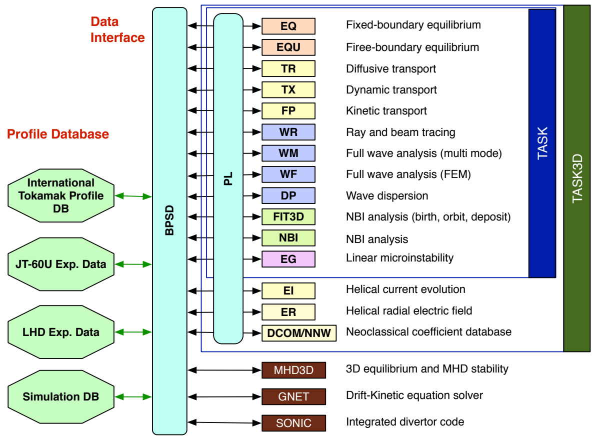

Fig. 3. Structure of integrated modeling code TASK

4. Summary

With the progress of integrated modeling of fusion plasmas, some kinds of integrated simulations require a large computer resources available at CSC. For the final goal of integrated modeling, development of reliable reactor plasma simulator with various levels of modeling, we have to make the best use of the computer resource at CSC.

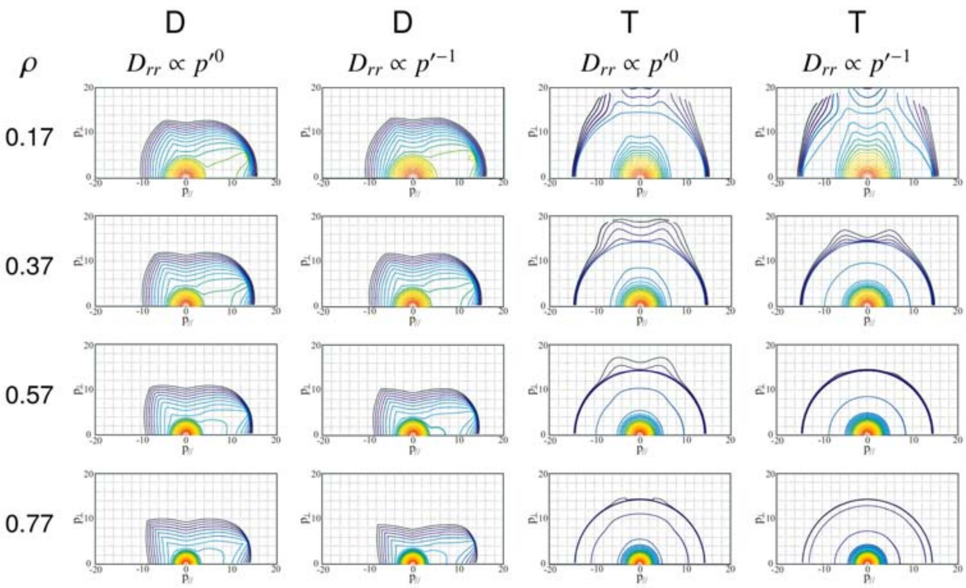

Fig. 4. Effect of momentum dependence of radial diffusion on distribution functions