

## 9. Department of Simulation Science

In order to clarify physical mechanisms that underlie many different layers of the experimental results, a large-scale simulation research is promoted utilizing fully the capacity of the super computer. Recently in a limited spatio-temporal hierarchy, the experimental results can be interpreted by a large scale simulation. Researches to connect such hierarchies that simultaneously deal with the turbulence and the magnetohydrodynamic macro instability are also developed. Upon these achievements, the simulation researches will be further promoted with the intensified collaboration.

The Department of Simulation Science established in 2007 consists of the Division of LHD and Magnetic Field Confinement Simulation, the Division of Fusion Frontiers Simulation, and Rokkasho Research Center. Besides, activities by the computer working group, the network working group, and the virtual reality taskforce are now being developed. Based on these, the Department promotes various research collaborations including interdisciplinary collaborations.

Furthermore, 3 new projects –LHD and magnetic field confinement simulation, laser fusion simulation, and plasma complexity simulation– were started. Through collaborative researches with universities and institutes, the Department is developing a model for the “hierarchy-renormalized simulation” that self-consistently renormalizes hierarchical interactions. With a view to improve a large-scale simulation environment, the Department is planning to significantly upgrade the performance of a plasma simulator (supercomputer). For such a purpose, a benchmark suit for plasma-fusion simulations has been prepared under the domestic collaborations, and several tests have been done by using various

platforms. Also, since it seems more appropriate to communize basic parts of fluid type of simulation codes in order to promote collaborative researches efficiently, the communized MHD code is to be released by the end of fiscal year 2008. Likewise, the first generation of hierarchy-integrated simulation codes is to be released in FY 2008. Thus, while improving the hardware and software simulation environment, the Department, together with collaborative researchers, will further develop a larger-scale simulation research that will lead to the LHD Numerical Test Reactor on the basis of the knowledge and information obtained through these simulation researches and developments.

Present role of Rokkasho Research Center is to carry out public relation activities as the Inter-University Research Institute, to collaborate with ITER (International Thermonuclear Experimental Reactor) and BA (Broader Approach) from the scientific standpoint, to promptly provide necessary information to universities, to develop the advanced algorithms for long fat network, and so on.

The memorial symposium for the establishment of the Department of Simulation Science Research was held in September of 2007 with researchers nationwide as well as foreign researchers to provide the opportunity to exchange opinions about the simulation research. The Department plans to hold this type of symposium on an annual basis around the same time of the year. Moreover, in order to promote collaborative researches more intensively, the computer working group and the network working group have continuously worked under the direction of the NIFS collaboration committee. Those activities like holding the symposium and operating computer and network will create a suitable circumstance for tight collaborations.

As stated above, our target is to strive to establish a new scientific area of research called "Simulation Science", which is different from experiments or theoretical studies, with a view to contribute for the realization of nuclear fusion energy while in cooperation with domestic as well as international collaborative researchers. Various computer simulation researches have been pursued in the framework of the simulation science, which include simulations related to magnetic fusion plasma physics, laser fusion plasma physics, space plasma physics, basic plasma physics, physics of molecular dynamics and so on, and also related area supporting computer simulations such as numerical technique, visualization technique, virtual reality technique, and network technique. Some of them are originally initiated by NIFS, and the others are initiated through the NIFS collaboration program. The NIFS collaboration program is important in order to deepen physics understanding and to extend the range of the simulation science. With the progress of the computer performance, the simulations based on the reduction to the elements or simulations in the mono-hierarchy are leading to the states that the simulations could explain and interpret the individual experimental phenomena. Thus, as a natural tendency, the paradigm shift is beginning from the simulations based on the reduction to the elements to those based on the integration of elements or simulations interconnecting various space-time scales or hierarchies in order to understand and predict a whole structure of the natural phenomena.

In order to develop such a predictive simulation code system, a hierarchy-renormalized simulation model is being developed, which consists of hierarchy-integrated simulation approach and hierarchy-extended simulation approach. The former model, - which is mainly based on a transport model with simple theoretical models representing physical processes in

various hierarchies -, is suitable to investigate the entire temporal behavior of experimentally observed macro physics quantities, and the latter model, - which is mainly distinguished into: fluid core plasma description, kinetic core plasma description, and peripheral fluid/ kinetic description with various physical processes -, is focused on the mutual interaction among neighboring hierarchies.

We hope that the newly established Department of Simulation Science will be useful for collaborative researches on theory and simulation, leading to the COE on the simulation science.

(Sudo, S.)