National Institute for Fusion Science April 2016 – March 2017

The most inevitable issue for mankind in this century is energy security. Energy resources alternative to fossil fuels are indispensable for a sustainable society, since there is expanding demand for energy on a global scale due to the explosive population growth and economic development concentrated in developing countries. In addition, the increase in greenhouse gases such as carbon dioxide due to continued use of fossil fuels and the depletion of fuel resources will become serious issues.

The realization of nuclear fusion energy can resolve the serious environmental and energy crisis which human beings are now facing. The fuels for fusion can be obtained from seawater, therefore the fusion energy is virtually inexhaustible. Furthermore, the fusion reaction does not emit carbon dioxide, thus fusion energy can be the ultimate clean energy. The fusion research around the world has progressed year by year based on the steady progress of basic science and advanced technology. On the other hand, critical scientific and technological issues which must be resolved to put this energy resource in our hands remain.

This annual report summarizes achievements of research activities concerning the fusion research at the National Institute for Fusion Science (NIFS) from April 2016 to March 2017. NIFS is an inter-university research organization, which conducts collaboration research programs under three frameworks, that is, General Collaboration Research, Large Helical Device (LHD) Collaboration Research and Bilateral Collaboration Research. More than 500 collaborating research themes were proposed by collaborators in universities or institutes across the country. Proposals from abroad are also included.

With comprehensive studies on fusion science, NIFS emphasizes its roles as an inter-university organization as well as a Center of Excellence in the development of human resources, pouring energy into education for graduate students who will realize the generation of fusion power in the future. Such an advanced education is performed mainly through the Graduate University for Advanced Studies (SOKENDAI). In addition, graduate students from partner universities across the nation are also accepted.

In order to promote the scientific and engineering research towards the realization of fusion energy, NIFS conducts three major projects.These are the Large Helical Device Project, the Numerical Simulation Reactor Research Project, and the Fusion Engineering Research Project. These three pillars stimulate each other and accelerate development of the first fusion demo reactor (DEMO). Short introductions and summaries for these three projects are described-below.

Large Helical Device Project

The Large Helical Device (LHD) is the world's largest stellarator/heliotron device that confines high temperature plasmas only by external coils. The LHD is equipped with superconducting coils, and, therefore, it has full capability for steady-state operation. Due to distinguished stability in both physics and engineering, the LHD has provided more than 144,000 plasma discharges in the 19 years since the initial operation. This large number of research opportunities has driven the progress not only in fusion research but also in innovative and interdisciplinary studies.

Every research theme is proposed on the domestic and international collaboration programs. All groups have their leaders from both NIFS and universities. A leader from abroad is sometimes assigned, according to the experimental theme. The experimental schedule is arranged and finally determined in the board meeting of the experimental groups, which consists of group leaders. The board meeting is responsible for all of the LHD experiment.

Numerical Simulation Reactor Research Project

The Numerical Simulation Reactor Research Project (NSRP) evolves the tasks in the theory and simulation research activities. Under the international and domestic collaborations on large-scale numerical simulation, the project is aims to understand and systemize physical mechanisms in fusion plasmas and to realize the numerical test reactor (NTR).

In the project, eight research groups are set up to cover a wide range of simulation subjects, i.e., 3D physics, equilibrium and stability, high energy particle, fueling, transport, turbulence, edge physics, plasma-wall interaction, and other basic plasma physics supporting fusion science. Simulation methodology such as multi-scale simulation modeling and scientific visualization is also studied. Most of the groups and themes are closely related to the LHD or general torus plasmas such as tokamaks. On the other hand, some members in each group are concerned which the basic plasma physics, such as solar and/or space plasma.

Fusion Engineering Research Project

Based on the experience and knowledge obtained so far in LHD experiments, the objectives of this project are focused on both the conceptual design of a steady-state fusion demonstration reactor and various engineering research and development, which are needed before entering into the engineering design activities for DEMO. This project consists of three research groups, i.e., reactor system design, superconducting magnets, and in-vessel components.

Along with a conceptual design of the helical reactor FFHR towards DEMO, by integrating design bases established so far on the designs of the FFHR series, the project is carrying out research on key components, such as the superconducting coil system, high performance blanket, first wall, divertor, and other topics. As the center of fusion engineering research for universities, the project enhances domestic and international cooperation to advance reactor design studies and R&D activities as well as to expand basic research in interdisciplinary areas.

In addition to the above mentioned 3 major projects which have well-defined missions, NIFS also supports interdisciplinary and basic research, and promotes the coordinated research for ITER-BA cooperation, laser cooperation, and academic-industrial cooperation.

Yasuhiko Takeiri
Director-General
National Institute for Fusion Science