6. Network-Type Collaboration

The NIFS General Collaboration has been basically based on a one-to-one (especially, NIFS-to-University) collaborative system. Some collaborations, however, require the use of more than one experimental facilities in different universities and institutes to achieve their objectives. For example, a special sample that was prepared in a university is exposed to plasmas produced in LHD, then it should be analyzed using a diagnostic instrument in another university. In the network-type collaboration, this type collaboration becomes practicable by admitting travel expenses for moving between universities, which have not been admitted as a rule in the general collaboration projects. Since FY 2011, NIFS has employed this network-type collaboration on trial as one of nine categories of the General Collaboration. Three projects of the different fields were accepted in FY 2011 for the first time and were continued in FY2012. Two more proposals were newly accepted in FY2012. The researches of those five proposals were continued in FY2013. Challenges of these collaborations spread over various fields.

Before starting the collaborations, a collaboration plan for the year should be submitted. They were including the items how the collaborations between research institutes were planned, i.e., who goes when and where by what kind of purpose.

The major achievements of these projects are outlined below. First three proposals (#1-#3 below) are continuing subjects since FY2011, and two proposals (#4 and #5) are continuing ones since FY2012.

1. "Collaborative Research of Magnetic Reconnection among Laboratory, Observation and Simulation", Ono, Y. (Univ. of Tokyo), et al.

   They promoted a new style of collaborative plasma research of magnetic reconnection among laboratory experiment, solar and magnetosphere observation and theory/ simulation by starting several joint research groups composed of Hinode solar satellite team, laboratory experiments at Univ. Tokyo, NIFS simulation team, NIFS diagnostic team, JAEA simulation team, and AIST NBI team. Their activities during three years are summarized in J. Plasma Fusion Res. 2013, No. 11-12, "Overview and Prospect – Frontier Researches in Magnetic Reconnection –" (by Y. Ono, et al) and also in Astronomical Herald 2013 No.6 (by N. Nishizuka) related with the joint experiment on light bridge by TS laboratory experiment and Hinode solar observations.
   Main collaborative achievements are as follows. Hinode-TS joint research team studied the plasmoid ejection phenomenon in solar chromosphere using solar satellites: Yohko/ Hinode and a spheromak/ tokamak plasma ejections in TS-2 experiment. NIFS-TS team investigated the cause and mechanism for reconnection heating using both of particle (PIC) simulations code developed by NIFS, and TS merging/ reconnection experiment in Univ. Tokyo. TS-NIFS-AIST-MAST joint team also studied the significant reconnection heating of ions and electrons up to 1.2 keV in the MAST experiment, exploring high-power heating/ startup of tokamak plasmas. They made about 10 invited talks and published about 20 journal papers related to this collaboration program.

2. "Effect of Active Control on Plasma Performance in Magnetically Confined Toroidal Plasmas", Masamune, S. (Kyoto Inst. Tech.), et al.

   In high-β toroidal plasmas such as Spheromak (SP), Field Reversed Configuration (FRC), Spherical Tokamak (ST), and Reversed Field Pinch (RFP), various methods for active control have been applied to realize improvement of plasma performance or to control plasma dynamics during MHD relaxation. They picked up various methods such as magnetic helicity injection for current profile control, neutral beam injection for heating or density profile control, inductive current drive for current density profile control, magnetic boundary control for MHD stability manipulation, Compact Torus (CT) plasma injection for helicity injection, and so on.

   In the research program, new collaborative experiments and theoretical works have been started. The machines involved in these experiments are HIST (SP) at Univ. of Hyogo, NUCTE (FRC) at Nihon U., TS-3 and 4 (SP, FRC, ST) and UTST (ST) at Univ. of Tokyo, RELAX (RFP) at KIT, and LHD at NIFS, with research topics related to active control. Theoretical works related to these collaborations include particle simulation at Gunma Univ., 3-D MHD simulation at NIFS, two-fluid MHD equilibrium and stability analysis at JCGA.

   In the second year 2012, they started some experimental and theoretical collaborative programs, with emphasis on encouraging students to participate in the activities. In 2013, corresponding to the third year, in addition to continuation of the collaboration, they made a brief summary for the three-year programs, with discussion of the prospects of expanding themes and participants for this type of collaboration.

3. "Hydrogen isotope – materials dynamics for recycling evaluation", Oya, Y. (Shizuoka Univ.), at al.

   Understanding of Plasma-Wall Interaction (PWI) is one of the most important subjects, especially, from viewpoint of the estimation of Hydrogen isotope recycling rate. Basic researches have been performed in many universities and institutes. In order to understand the Hydrogen isotope recycling phenomena and the behavior of Tritium in the actual fusion reactor, it is particularly important to evaluate the Hydrogen isotope retention rate of samples exposed to plasmas in the fusion-intended big devices. They presented the comparison of hydrogen isotope retention enhancement for tungsten exposed to plasma during the experimental campaigns in 2011 and 2012 at LHD.

   The mirror finished disk-type tungsten samples were placed into in four typical positions in LHD. These samples were exposed to ∼5000 shots for 2012 long-term plasma campaign. In 2012 campaign, the closed divertor structure, which consists of graphite parts, was installed in 8 sections to enhance the plasma performance, although that in 2011 campaign was 2 sections. The samples were picked up and transfer to Shizuoka University. The 1.0 keV deuterium ions (D_2^+) were additionally implanted into these samples. The hydrogen isotope retention was evaluated using TDS in Shizuoka Univ., GDOES in Univ.of Toyama, and TEM in Kyushu Univ..

4. "RF Plasma Generation and Current Ramp-up Experiments on Spherical Tokamaks", Takase, Y.(Univ. of Tokyo), et al.

   The purpose of this research is to investigate experimentally the physics of spherical tokamak plasma formation and plasma current ramp-up using radiofrequency (RF) waves as network collaboration among Univ. Tokyo, Kyoto Univ., Kyushu Univ. and NIFS.

   Compared to advancing research independently on each device, it becomes possible to make more efficient progress towards developing understanding of universal physics by unifying the results obtained on both devices using complementary methods, utilizing the network-type collaboration framework.

   In FY2013, several collaborations were conducted. Toroidal and poloidal flows as well as the ion temperature were measured successfully in TST-2 plasmas using a newly developed mechanism to switch between toroidal and poloidal sightlines. In LATE, first results of electrostatic potential measurements are being obtained. It would become possible to characterize the equilibrium of RF generated plasmas combining the results of potential and flow measurements.

   Three kinds of probes are being developed collaboratively by Univ. Tokyo and Kyushu Univ. Those are the array of electrostatic RF probes, the turbulence probe consisting of a Mach probe with a three-axis magnetic probe, and the Rogowski probe consisting of a Rogowski coil with a three-axis magnetic probe.

5. "Study of Current Decay Time during the Discharge Termination of Plasmas in Toroidal Magnetic Field", Watanabe, K.Y., et al.

   The purpose of this study is the adept understandings of the termination mechanism and the behavior of the toroidal plasma current during the discharge termination from the viewpoints of the interaction between the properties of plasma confinement and MHD equilibrium through the comparative analysis on the current behavior during the termination among some magnetic confinement systems which have various MHD equilibrium properties. In addition, another purpose is the promotion of the research activities related with the MHD equilibrium and instability in universities by utilizing their experimental devices. The research subject and the researchers are organized into the following three subjects and groups by topic; (1) improvement of the prediction code, (2) development of the identification methods of MHD equilibrium in experiments (3) analysis of the current decay behavior. A lot of researchers and students in many universities and institutes involve in the collaboration.

   Related with these topics, two subjects are proposed as the FY2014 NIFS collaborated programs through the discussion. One is the experimental study on the penetration of the Resonant Magnetic Perturbation (RMP), and another is the confirmation of the identification method of the eddy current on the experimental device. The education over a university through the network-type collaboration, is also important, e.g., initiation of the usage of the calculation code and the usage of the device operation by the researchers who belong to the other universities and/or the institutes.

(Shimozuma, T.)