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. 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 from FY2011, and two proposals (#4 and #5) are newly accepted ones in FY2012.

1. "Hydrogen isotope – materials dynamics for recycling evaluation", Oya, Y. (Shizuoka Univ.) *et al.*

   Understanding of Plasma-Wall Interaction (PWI) is one of the most important subjects, especially, from viewpoint of the estimation of Hydrogen recycling rate. Basic researches have been performed in many Universities and Institutes. In order to understand the Hydrogen recycling phenomena and the behavior of Tritium in the actual fusion reactor, it is particularly important to evaluate the Hydrogen retention rate of samples exposed to plasmas in the fusion-intended big devices. In this collaboration, they have a plan to utilize plasmas in LHD (NIFS), QUEST (Univ. of Kyushu) and GAMMA 10 (Univ. of Tsukuba) as exposure sources and evaluate the sample using the analyzing instruments and/or small-scale irradiation devices in Universities of Shizuoka, Hokkaido, Toyama, Shimane and Nagoya. Therefore, this collaboration is expected to be a typical one in which the network-type collaboration will effectively work.
   Tungsten will be used as a primary candidate material for plasma facing materials due to its lower tritium retention and high thermal conductivity. It is important to predict actual tritium retention in plasma facing materials, which was modified by plasma exposure. In this study, tungsten samples were exposed to hydrogen plasma during 16th campaign in LHD. Thereafter, the additional deuterium ion was implanted into these samples at Hokkaido University and the enhancement of hydrogen isotope retention was studied. The deuterium TDS spectrum for a sample at 16th campaign consisted of two desorption stages at around 600 and 800-1000 K. These desorption stages were attributed to the desorption of deuterium trapped by tungsten and the deposition layer, respectively.

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

   In high-beta 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 FY2012, many mutual collaborative researches have been started following the review trips made in FY2011. Design studies, experiments and simulation works were performed between two or three University groups. The obtained results of these collaboration were presented at US-Japan MHD Workshop, EPS Conference, US-Japan CT Workshop, IAEA Fusion Energy Conference, Annual Meeting of JSPF, and so on.

3. "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. These activities finally lead to the first joint paper on the light bridge by collaborative works of TS (Univ. Tokyo) laboratory experiment and Hinode solar observations.
Main collaborative achievements are as follows. Hinode-TS joint research team simulated the light-bridge phenomenon in solar chromosphere using a spheromak plasma with center solenoid flux in TS-4 ST devices of Univ. Tokyo.
NIFS-TS team investigated the cause and mechanism for reconnection heating by using both of particle (PIC) simulations code developed by NIFS and TS merging/ reconnection experiment in Univ. Tokyo.
TS-NIFS-AIST-MAST joint team demonstrated the significant reconnection heating of ions and electrons 0.2keV in TS-3 experiment and 1.2keV in the MAST experiment, indicating that the reconnection heating is useful for high-power heating/ start-up of tokamak plasmas.

They made about 10 invited talks and published about 20 journal papers related to this collaboration program.

4. "Study of Determination Mechanism of Plasma Current Decay Time during the Discharge Termination Phase in Toroidal Magnetically Confined Plasmas", Watanabe, K.Y.

The final goal of this study is to obtain the common physical pictures of the determination mechanism of the current decay time through the comparative analyses of the current decay behaviors during the discharge termination for the various magnetic confinement plasma devices with the various MHD equilibrium characteristics. Special attention is focused on the interactions between the plasma confinement and the MHD equilibriums. Furthermore, it is also important to promote the research activities on the MHD physics of the toroidal plasmas in the Japanese Universitiesf research groups, because MHD research groups is a few in the Japanese Universities. In FY2012, the researches were progressed by the following two task groups, so called, "current decay analyses" group and "current decay analyses" group.

In the "current decay analyses" group, they study the current decay analyses of the tokomaks. The tuning-up of the prediction code of the current decay behavior, i.e. the DINA code, during the discharge termination has been done by the collaborators in Nagoya Univ., Kyoto Univ., NIFS and JAEA. They apply the tuned-up code to the current decay analysis in the JT-60 disruption discharges, which has the detail measurement data of plasma parameters during the disruption phase.

In the "MHD equilibriums identification method developing" group, they develop the identification method of the MHD equilibrium for the various magnetic configurations, such as helical and REP devices, to apply it and to make the validation of the efficiency.

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

The goal of this collaboration is to study experimentally the generation of plasma and the ramp-up of the plasma current by radiofrequency (RF) waves in spherical tokamaks (STs) such as TST-2 in Univ. of Tokyo and LATE in Kyoto Univ., under collaboration among Univ. of Tokyo, Kyoto Univ., Kyushu Univ. and NIFS.

The Network-type Collaboration of NIFS enables attempts to develop understanding of universal physics efficiently by integrating the results obtained on the two complementary devices, instead of working independently on each device as in the past.

In FY2012, several collaborations were conducted. The first collaboration is X-ray spectral measurements in the intermediate energy range on TST-2 with CdTe detectors being used on LATE. Second one is microwave interferometers on LATE which were improved by suggestion from TST-2 group. On LATE, ion temperature was also measured using high-resolution visible spectrometer ever used in TST-2. The measured ion temperature was found much higher than expected. Between Kyushu Univ. and the Univ. of Tokyo, a new electrostatic RF probe for measuring RF waves is being developed. The eventual goal is to measure the wave-vector of the RF wave using an array of electrostatic RF probes.

(Shimozuma, T.)