6. Personal Interchange Joint Research Program

Although NIFS provides many types of joint research programs that cover a variety of researches on nuclear fusion or plasma physics, many original ideas and the extensive studies are also carried out in university laboratories and other institutes. Sometimes, they are complementary to the specific projects of NIFS, and worth to be supported by NIFS.

Personal interchange joint research program has been established for this purpose. Being different from other collaboration programs of NIFS, where the university researchers come and join the research activities held at NIFS, this program supports financially that the staff of NIFS goes out to join the collaboration research in universities. Two categories are prepared for collaboration; one is "project type" where the collaboration is made between two facilities; one is at NIFS and the other is at the university. A systematic research on the common subjects is done at both facilities by the researchers of both organizations to obtain a comprehensive knowledge on the subjects. The other is "detach type" where the researchers of NIFS take part in the study using the facility or experimental device at the university with a new idea or with an expert knowledge to explore a new field.

In this year, five subjects were carried out as "project (P) type" and seven for "dispatch (D) type". Among them, the results of seven subjects are reported here, and brief summaries of each subject are listed below.

[P 1]: *"MHD characteristics in an extremely high-beta torus plasma," by AsaiT. et al.*

This collaboration was carried out between NIFS Nihon Univ. and Gumma Univ. on the study of MHD stability of Field Reversal Configuration plasma of NUCTE-III. The radial profile of toroidal velocity was observed by neasuring CV line, and is almost flat in the very early phase of FRC discharge pulse. However, the acceleration rate of rotation velocity outside of the separatrix is smaller compared to the outside. It indicates the existence of velocity shear in the vicinity of the separtrix. The stability effect of this observed shear on higher toroidal mode number of interchange instability could be a reason why the higher mode of toroidal deformation predicted in the theoretical works has never been observed in the FRC experiments.

[P 2]: *"Development and application of high performance THz gyrotron," by Saito T. et al.*

This is a collaboration research program between NIFS RF heating group and the Research Center for Development of Far-Infrared Region, Univ. of Fukui (FIR FU) to develop THz gyrotron. They have started a collaborative study for development of a sub terahertz gyrotron for collective Thomson scattering (CTS) in LHD based on this plan. They refer to this gyrotron as the first step gyrotron. In the experiment of the first step gyrotron, single mode second harmonic oscillation has been observed in the range of 400 GHz. This frequency range is preferable for CTS in LHD.

[P 3]:*"Control of ion acceleration by RF waves in a fast-flowing plasma," by Ando A. et al.*

This subject was carried out between NIFS Plasma heating group and the group of Tohoku University. The purpose of this research is to investigate an ion heating and acceleration phenomena in a fast-flowing plasma using a magnetic nozzle in order to control the flow energy. The thermal energy was converted to flow energy successfully by passing through the diverging magnetic nozzle. The energy conversion occurred so as to keep the magnetic moment μ constant. It was also found that an electric field in the direction of ion acceleration was generated with RF excitation, which was caused by the ambipolar effect along the magnetic field, and the potential profile well corresponded to the Boltzman's equation considering the density decrease..

[D 1]: *"Measurement of dynamic properties of pulse modulated induction thermal plasmas using Langmuir probes," by Uesugi Y. et al.*

The plasma characteristic of Inductively Coupled Thermal Plasma (ICTP), which is called Pulse-Modulated Induction Plasma (PMITP), is investigated. The PMITP is thermal plasmas under the periodical transient state by amplitude modulation of coil current maintaining ICTP. This plasma has possibilities of controlling thermal plasma temperature and radical density in time domain. In this work, dynamic behavior of electron density and temperature are investigated in Ar-PMITP using Langmuir probe. High pressure argon-hydrogen mixture plasmas have been used to study graphite erosion by low energy hydrogen irradiation.

[D 2]: *"Analysis of T_c, J_c and H_{c2} properties for low activation superconducting wires," by Hishinuma Y. et al.*

This is a program between NIFS and NIMS (National Institute for Material Science) on developing low activation superconducting materials. V-based compound and alloy may be applied for a future fusion magnet because they have shorter decay time of induced radioactivity compared with Nb-based superconductor. Small amounts of Cu addition MgB_2 compound mono-cored wires were made by the PIT process using Mg (99.9%, -200 mesh), Mg_2Cu compound and amorphous B powders (99.9%,-submicron). J_c property under the high magnetic field was measured by using various High-Field Superconducting Magnet systems in Tsukuba Magnet Laboratory of NIMS (TML-NIMS).

[D 3]: *" Development of cesium-free deuterium negative ion source with grid bias method," by Fukumasa O. et al.*

This research program is to investigate the possibility of controlling plasma parameters, in particular Te, with grid bias method in rf-driven plasmas, and to realize negative ion production in rf plasmas and to discuss the difference in Te control and H- production between the mesh grid (MG) bias method and the magnetic filter (MF) method. In the case of MF, although Te is decreased by increasing the field intensity of the MF, at the same time, ne is also decreased more drastically. In the MG bias method, high energy electrons pass the mesh and enter into the extraction region. As a result, ne increases in its value with z and reaches the maximum value and then decrease while Te decreases in its value and keeps nearly equal to or lower than 1 eV. This is suitable condition for negative ion volume production. Therefore, the MG bias method is more suitable to optimize plasma conditions for negative ion volume production, compared with the MF method.

[D 4]: *"Heating and current drive experiments on the TST-2 Spherical Tokamak," by Takase Y. et al.*

The purpose of this collaborative research is to perform heating and current drive experiments using radiofrequency (RF) waves on spherical tokamak (ST) plasmas. This research aims at establishing the scientific basis for RF heating and current drive in plasmas with very high dielectric constants, with the eventual objective of developing innovative methods for plasma start-up and steady-state sustainment. The preparation of lower hybrid current drive and plasma current start-up experiments on TST-2 has started by collaboration between the University of Tokyo RF group and the NIFS RF group during in this Fiscal Year.

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List of reports

P 1. "MHD characteristics in an extremely high-beta torus plasma," by Asai T. et al. (Nihon Univ.).
P 2. "Development and application of high performance THz gyrotron," by Saito T. (Fukui Univ.).
P 3. "Control of ion acceleration by RF waves in a fast-flowing plasma," by Ando A. (Tohoku Univ.).

D 1. "Measurement of dynamic properties of pulse modulated induction thermal plasmas using Langmuir probes," Uesugi Y. (Kanagawa Univ.)
D 2. "Analysis of T_c, J_c and H_{c2} properties for low activation superconducting wires," Hishinuma Y. (NIFS).
D 3. "Development of cesium-free deuterium negative ion source with grid bias method," Fukumasa O. (Yamaguchi Univ.).
D 4. "Heating and current drive experiments on the TST-2 Spherical Tokamak," Takase, Y. (Univ. Tokyo).