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, eight subjects were carried out as "project (P) type" and nine for "dispatch (D) type". All the programs have been done successfully, and brief summaries of each subject are listed below.

[P 1]: *"Ion heating and acceleration 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 on the study of ion heating and magnetic nozzle acceleration in fast-flowing plasma. In this configuration, flowing plasma is heated by ICRF the frequency of which is 100 – 500 kHz. The ion heating was observed when the magnetic field strength coincides with the ion cyclotron resonance frequency.

[P 2]: *"Measurement of edge plasma fluctuation by 2-D thermal Li beamt," by Ohno N. et al.*

This subject was carried out between Nagoya Univ. and NIFS on the measurement of scrap-off layer by using lithium ion beam probe. In order to carry out to measure two dimensional density fluctuation in the SOL, an efficient thermal lithium beam is required. A new lithium oven was designed for this purpose, and initial test showed good performance. A new lithium ion source was fabricated according to these results.

[P 3]: *"Study of Electron Heating by using Electron Bernstein Wave in Ultra High Beta Plasmas," by Kawamori E. et al.*

This collaboration was carried out between NIFS Univ. Tokyo on the heating and current drive by using electron Bernstein wave (EBW). Microwave of 2.45GHz is launched in X-mode to the Reversed Field Configuration plasma. The reflection of RF power was very large in the experiment, which agrees with the result of numerical simulation. Higher magnetic field strength is required to improve the efficiency.

[P 4]: *"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. Experiments and analyses on oscillation, stability of power and frequency of gyrotrons were made by the team of FIR FU, and these results were examined by the members of NIFS. The radiation pattern of output of FU CW I, which is a completely CW 300 GHz gyrotron, was measured by an infrared camera. The radiation pattern revealed a multi-peak character in the range of the cathode voltage and the magnetic field strength at the cavity. Simultaneous oscillation of multi modes was confirmed.

[P 5]: *"Study on various atomic processes of impurity highly charged ions by versatile ion sources," by Nakamura N. et al.*

This is a collaboration research program between NIFS NICE group and the Tokyo-EBT group of ILS, Univ. Electro-Com. The aim of the research is collecting and evaluating relevant atomic data of highly-charged ions of heavy elements. In this year, the dielectric recombination (DR) of H-like Fe was investigated in Tokyo-EBIT. DR is the most important radiation energy-loss process of high temperature plasmas containing heavy impurity elements.

[P6]: *"Electron Bernstein wave heating by long wavelength microwave in a spherical tokamak and a helical device," by Maekawa T. et al.*

This program has been continued as a collaboration between Kyoto university LATE group and the NIFS CHS group on developing electron Bernstein wave (EBW) heating, which is crucial to produce high density plasma in both devices. In LATE spherical tokamak, plasma and toroidal current are initiated successfully by ECH alone using two frequencies; 2.45GHz and 5GHz. In both cases plasma is considered to be heated by mode-converted EBW because the obtained density is higher than that for cut-off. Judging from the heat load by fast electrons that are considered to be produced by EBW, resultant coupling of injected microwave to EBW is fairly high.

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

MHD behaviors were studied in a negative biased theta pinch at Nihon University, NUCTE-III, using

tomography. A time evolution of two dimensional emission profile of the bremsstrahung was reconstructed by the ART method. It was found that the FRC deforms into a dumbbell-like structure before the edge hits the chamber wall prior to the disruption phase. In addition, an internal shift mode with a toroidal mode number n = 1 has been observed in the equilibrium phase followed by growth of n = 2 rotational instability. Several new diagnostics have also been developed to investigate the MHD behavior. By a optical fiber with a large numerical aperture covering the entire plasma, a detector system for a plasma position and structure measurement has been improved. A time evolution of a center position of the separatrix and n = 1 and 2 mode deformation along the z axis was observed for the first time.

[D 2]: *"Measurement of dynamic properties of pulse modulated induction thermal plasmas using Langmuir probes," by Uesugi Y. et al.*

Inductively coupled thermal plasmas (ICTPs) has great advantages such as high gas temperature, high radical density and little impurity contamination. Pulse-Modulated Induction Thermal Plasma (PMITP) is a new type plasma source of Kanagawa Univ. where thermal plasma is generated under transient state by periodical amplitude modulation of a induction coil current. Plasma parameters were investigated by Langmuir probes. The electron density changes synchronously with the rf power modulation, but the electron temperature shows a different behavior from that of the electron density.

[D 3]: *"Experimental Study of Electromagnetically Induced Transparency in Magnetized Plasma," by Kawamori E. et al.*

Electromagnetically induced transparency (EIT) is a well-known phenomenon in which the optical properties of a medium, such as absorption and emission, are dramatically modified as a result of superposition of quantum states of the medium when irradiated by two lights. In plasma it shown that the electron cyclotron resonance absorption of electromagnetic right-hand polarized wave does not occur in the presence of a second, properly frequency tuned, electromagnetic pump wave, that is, plasma can be made transparent at the cyclotron frequency. The experimental demonstration of this phenomenon is planned, and a basic design has been done.

[D 4]: *"Rotating Magnetic Islands Driven by External Perturbation Fields in TU-Heliac," by Kitajima S. et al.*

The purposes of the experiment in TU-Heliac Tohoku Univ. are, to study the ability of the poloidal rotation of islands by rotating perturbation fields, and to check experimentally the structure of islands by measurement of plasma radial profiles by Langmuir probe. The magnetic field configuration was selected to locate a rational flux surface (n/m = 5/3) in the plasma periphery. The external perturbation coil was introduced, and the possibility of the poloidal rotation of islands was explored by numerically changing the phase of the each perturbation coils current. The existence of island was confirmed by Langmuir probe measurement experimentally.

[D 5]: *"Heating and current drive experiments on the TST-2 Spherical Tokamak," by Takase Y. et al.*

This research program is to perform heating and current drive by RF wave on a spherical tokamak of university of Tokyo (TST-2). The preparation of RF heating experiments on TST-2, including improvements to and testing of the high-power transmitters, adjustment of impedance matching, and high power testing of the antenna, was carried out by collaboration between the University of Tokyo RF group and the NIFS ICRF group. A diagnostic to measure the excited wave in the plasma interior using microwave reflectometry was developed on TST-2.

[D 6]: *"Analysis of J_c properties in high magnetic fields 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. They approach V3Ga compounds as V-based low activation and high magnetic field superconducting materials for fusion application. In order to improve superconducting property of V3Ga compound, a new processing using high Ga content Cu-Ga compound and metal V matrix was developed.

[D 7]: *"Equilibrium Analysis of Quasi-Single Helicity State in a Reversed Field Pinch Plasma," by Hirano Y. et al.*

In the Quasi-Single Helicity (QSH) state of Reversed Field Pinch Plasma, a certain toroidal Fourier mode (mode number, n) in the magnetic fluctuation of m = 1 mode selectively grows and the plasma becomes semi-helical state. Because helical structure was also observed in LHD at very high density, it was tried to extend the operation regime of QHS to higher density by strong gas puff. However, QHS was shifted to Locked Mode under the strong gas puff, and the helical structure disappeared.

[D 8]: *"Adsorption and Desorption Behavior of Tritium in the Plasma-Facing Materials," by Matsuyama M. et al.*

To examine the detritiation methods corresponding to the release rate and the chemical form of tritium species is required for the DD experiments in LHD. In Hydrogen Isot. Res. Center, Toyama Univ, the absorption and desorption behavior of tritium was studied on the samples of stainless steel type 316L (described as SS316L), which was widely used as a structural material in the vacuum chamber of LHD. After samples were exposed to the tritium molecules 3 hours at 350 C, the release rate and the chemical form of tritium were examined under argon atmosphere at room temperature. The release rate was very fast just after the sample was taken out, but it drastically dropped down and a steady rate was observed.

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List of reports

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P 2. "Measurement of edge plasma fluctuation by 2-D thermal Li beamt," Ohno N. (Nagoya Univ.).
P 3. "Study of Electron Heating by using Electron Bernstein Wave in Ultra High Beta Plasmas," Kawamori E. (Univ. Tokyo).
P 4. "Development and application of high performance THz gyrotron," Saito T. (Research Center for Development of Far-Infrared Region, Fukui Univ.).
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