6. Personal Interchange Joint Research Program

NIFS provides many types of joint research programs that cover a variety of researches on nuclear fusion or plasma physics. On the other hand, 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 staffs of NIFS go 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 "dispatch 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, four subjects were carried out as "project (P) Type" and eight for "dispatch (D) type". The results of all subjects are reported here, and brief summaries of each subject are listed below.

[P1]: *"Excitation Experiments of Electron Bernstein Waves on the Internal Coil Torus Device " by Ogawa Y., et al.*

This collaboration was carried out between NIFS and University of Tokyo on the excitation of electron Bernstein waves (EBW) on the internal coil torus device. In the experiments, they have detected electrostatic waves with short wavelength that is a feature of EBW. In addition, by using magnetic loop antennas, electromagnetic mode waves have been measured in order to investigate characteristic of propagation and mode conversion of electromagnetic waves. Dispersion relation shows that X mode wave exists at UHR on the eve of mode conversion. Therefore the short wavelength mode can be identified with this X mode wave.

[P2]: *"Plasma simulation experiments using versatile highly charged ion sources" by Nakamura N., et al.*

This collaboration was carried out between NIFS and Univ. of Electro-Communications to obtain atomic data of highly charged ions such as the cross sections of resonant recombination and ionization processes. Those data are important as fundamental atomic data in non-equilibrium plasmas such as the peripheral plasma in fusion devices and the transition region in the solar atmosphere. For spectroscopic studies of iron ions relevant to the solar corona, a compact EBIT was used. Typical result for the electron density dependence of line intensity ratio of Fe XIII shows good agreement between the experiment and the theory. The present results proved that the compact EBIT is a powerful device for simulating the spectra of iron ions in the solar corona. They are currently preparing a fast electron beam control system to simulate plasmas with an arbitrary electron velocity distribution.

[P3]: *"Plasma heating and flow control in a fast-flowing plasma" by Ando A., et al.*

This subject was carried out between NIFS RF heating group and Tohoku University. The production and control of fast-flowing plasma are important to clarify various MHD phenomena observed in space and fusion plasmas, for developing advanced electric propulsion systems and for applying in various industrial researches. The purpose of the research is to evaluate and control plasma flow Mach number by various magnetic nozzles. They have newly developed an Alfven Mach probe, which is composed of a conventional Mach probe and a magnetic probe. They have measured various plasma parameters with several noble gas species (He, Ar, Ne, Kr). Effects of magnetic configuration, discharge current, and gas pressure, are investigated in order to evaluate mass effect of the working gases.

[P4]: *"Study of Plasma Responses to Stationary and Oscillatory Magnetic Perturbations in Two and Three Dimensional Tori " by Toi K., et al.*

This collaborative research aims at getting comprehensive understanding of interaction between resonant/non-resonant magnetic perturbations (RMPs/NRMPs) and two types of toroidal plasmas in LATE of Kyoto Univ. and LHD. Complementary studies are being performed both in LHD and LATE. In LHD, the effects on edge transport barrier (ETB) were studied by application of the so-called local island divertor (LID) field. The transition to ETB formation occured at the lower electron density than that without the LID field. On the other hand, effects of RMPs/NRMPs on current startup in LATE are interesting, because the magnetic perturbations may have a potentiality to control the amount of the trapped energetic electrons more effectively. Plasma responses to alternating magnetic perturbations in the frequency range of Alfvén eigenmodes(AEs) provide the information of the safety factor. The method can be applied to the LATE plasma to get the information of the safety factor on the nested magnetic surfaces generated during current startup.

[D1]: *"Measurement of Electron Bernstein Wave Emission from Ultra High Beta Plasmas " by Ono Y., et al.*

This experimental proposal aims to investigate feasibility of electron heating in extreme high-beta plasma by electron Bernstein wave (EBW). EBW is a method to overcome a density limit by which accessibility of conventional electron cyclotron resonance heating is limited. To this end, electron Bernstein wave emission (EBE) measurement was employed for compact torus experiments TS-3, which is an inverse process of mode conversion of EBW heating. The EBE system (2-2.5GHz) was applied to TS-3 FRC plasma experiment after installation of the system. Significant signal was detected during the discharge period, though the identification of the signal from the FRC plasma has not yet been completed,.

[D2]: *"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. The preparation for lower hybrid current drive and plasma current start-up experiments on TST-2 was continued by collaboration between the University of Tokyo RF group and the NIFS RF group during Fiscal Year 2009. An output power of 100 kW into the dummy load was achieved from each of the four 200 MHz transmitters. For current drive experiments, the combline antenna used previously on the JFT-2M tokamak has been transferred from JAEA to the University of Tokyo, and was modified for use on TST-2. This antenna will be installed in early FY2010, and plasma current ramp-up experiments will begin soon thereafter.

[D3]: *"Design Fabrication of Tritium Gas Infusion System" by Kawano T., et al.*

This research program is to develop a tritium gas monitor with sufficient sensitivity to be able to detect the tritium concentration limits regulated in the law. In the monitor, a proportional counter is employed as a tritium gas detector and methane gas is used as the counting gas for reducing the influence of radon in the exhaust air. They designed and fabricated a tritium gas infusion system to make a performance test using actual tritium gas for evaluating the monitor precisely. The tritium gas infusion system fabricated was partly tested its performance and precise examination will be planned.

[D4]: *"Development of High Power Sub-Terahertz Pulse Gyrotron " by Saito T., et al.*

Development of a high power sub-terahertz pulse gyrotron is under way with collaboration between Univ. of Fukui (FIR-FU) and NIFS for application to collective Thomson scattering (CTS) from a high density plasma in LHD. As the first step, a second harmonic gyrotron of demountable type was fabricated and tested. Experiments have proved single mode oscillation of second harmonic modes and oscillation power 50 kW at 350 GHz with the TE6,5 mode and 40 kW at 390 GHz with the TE8,5 mode. These values are the world records as second harmonic oscillation in the frequency range around 400 GHz. In FY2009, they have fabricated a sealed-off gyrotron with the same electron-gun and cavity design for precise assembly and good vacuum condition. The experiment is now in the process of aging. The second harmonic oscillations with around 350 GHz and 390 GHz have been identified. The oscillation efficiency at the beam voltage of 50 kV is much higher than that of the demountable type gyrotron. They will promote the experiments with higher beam voltage and beam current.

[D5]: *"Development of External Control Knob for Improved Confinement Mode in TU-Heliac" by Kitajima S., et al.*

Study of magnetic island effects on the transport is important, because it leads to the advanced control method for a plasma periphery in a fusion reactor. This research is to investigate island effects on confinement modes in Tohoku University Heliac (TU-Heliac). The island effects on the plasma periphery by the external perturbation fields in TU-Heliac were surveyed The experiment shows that the radial electric field at the inner edge of the island increased after perturbation field applying. The positions of local maxima in the plasma space potential profile agree well with the position of the $n/m = 5/3$ rational surface. The potential profile in the island grew according to the perturbation field strength. The full width at half maximum of the potential profile was found to depend on the square root of the perturbation field coil current.

[D6]: *"Development of the Feedback Control System for Modulated Induction Thermal Plasma (FBC-MITP) " by Uesugi Y., et al.*

This research is to investigate the frequency dependence of the thermal plasma temperature control by a feedback control for modulated induction thermal plasmas(FBC-MITP). The FBC-MITP has been newly developed originally by the authors to give a direct controllability of thermal plasma temperature. The newly developed FBC-MITP directly controls its temperature at the observation region to follow an externally given waveform. To control the temperature, spectrometric observation department and DSP were added to previous system. The frequency dependence of the FBCMITP system was investigated by adopting a sinusoidal waveform as a modulation signal and then by changing its frequency. The results showed that the FBC-MITP could follow the thermal plasma temperature according to a given waveform up to about 100 Hz.

[D7]: *"Development of Cesium-Free Deuterium/ Hydrogen Negative-Ion Source with Metal Catalectic-Ionization Method " by Oohara W., et al.*

This subject was carried out between Yamaguchi Univ. and NIFS NBI group. Development of deuterium/hydrogen negative-ion source without cesium admixture is performed upon surface production of atomic

ions on porous catalysts with discharged-plasma irradiation. The production property of hydrogen ions is firstly investigated using a porous Ni plate as a catalyst. The amount of ions produced from the catalyst surface increases in proportion to the irradiation current under the irradiation energy fixed. The production mechanism of the ions is considered to be completely different from conventional production mechanisms of converter type and cesium-seeded type, which is based on an electronic transition of metals with low work functions. Hydrogen atoms, produced by dissociative adsorption, are covalently bound with the surface-metal atoms, and can easily move along the surface. Hydrogen atoms migrate along the pore surface in the porous catalyst to the back side of the irradiation plane. They consider that an electronic transition occurs between the surface-metal atoms and hydrogen atoms during desorption from the surface.

[D8]: *"Analysis of Superconducting Properties of MgB_2 Superconducting Wires under Liquid H_2 Temperature " by Yamada S., et al.*

They have proposed that the simultaneous transport both superconducting power transmission and liquid hydrogen as the new energy sources, which is so-called " Hybrid Energy Transfer Line (HETL) ". They have developed Cu addition MgB_2 superconducting cable made in NIFS under liquid hydrogen temperature (20 K). In the research, its Ic-B performances under various temperatures from 4.2 K to 30 K were measured to investigate high Jc around high temperature region. The experimental results were satisfied with the conceptual design of 10 kA class HETL, and the prospect for the 20 K operation superconducting cable is obtained by the applying MgB_2 wire.

(Shimozuma, T.)

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