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, three subjects were carried out as "project (P) type" and nine for "dispatch (D) type". Among them, the results of ten subjects are reported here, and brief summaries of each subject are listed below.

[P1]: *"Control of ion acceleration by RF waves in a fast-flowing plasma," by Ando A. et al.*

This subject was carried out between NIFS rf heating group and 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. When the RF power increased, the plasma thermal energy increased almost linearly with power at first, but it tends to saturate. This is because the Larmour radius of heated ions becomes large to be comparable to the plasma radius, and are lost.

[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 on the study of atomic data of highly charged ions. 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 sun's atmosphere. The purpose of the present study is to make active contribution to the understanding of such nonequilibrium plasmas by obtaining experimentally simulated spectra emitted from highly charged ions interacting with electrons that have an arbitrary velocity distribution, that is, "temperature". As a test run, EUV spectra of highly charged Sn ions is obtained by using the fast-energy-conrtolled electron beam with the simulating temperature of 400eV, which is clearly different from the one obtained by mono-energetic electron beam of 400eV.

[D1]: *"Development of cesium-free deuterium negative ion source with grid bias method," by Fukumasa O. et al.*

This research program is to investigate the isotope effect on H^- and D^- production is investigated in dc plasmas with the magnetic filter, and to try the surface production of H^+ and H^- on porous catalysts with hydrogen plasma irradiation. The stronger magnetic filter fields are required to control of T_e in D_2 plasmas. the efficiencies of the negative-ion production in the H_2 and D_2 plasmas are different under the same discharge condition and the optimum control of the plasma parameters by external parameters needs to reveal. The new development of surface production method is tried using nickel porous catalysts. Hydrogen plasma produced by PIG discharge is irradiated to the porous plate, and the positive and negative ions are produced from the backside of the porous plate. The ionic plasma without electrons is generated downstream from the porous catalyst.

[D2]: *"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. MgB_2 compound shows superconductivity with high critical temperature (T_c) of 39 K and hence MgB_2 wire may be suitable for 20 K option of nuclear fusion reactor. The critical current density (J_c) properties of the MgB_2 wires was studied in high magnetic fields under the various temperatures such as 4.2, 10, 15 and 20 K. and it was found that Cu addition enhanced J_c-B property remarkably. We tried to fabricate Cu additional MgB_2/Ta/Cu multi-filamentary wires, and tested. Transport I_c of multi-filametary wire was lower than that of mono-cored wires, however core J_c was improves drastically. We also observed clearly the lowering of I_c value by the bending strain.

[D3]: *"Measurement of Electron Bernstein Wave Emission from Ultra High Beta Plasmas," by Ono Y. et al.*

This research program is to apply Electron Bernstein Wave (EBW) to heating of an ultra high-beta (volume average beta $\geq$ 80%) plasma. In order to study of the mechanism, a diagnostic system of electron Bernstein wave emission (EBE) was developed for compact torus experiments, which is an inverse process of mode conversion of EBW heating. The electromagnetic wave emitted from the plasmas is detected by a waveguide antenna and is transmitted to a detector module through a waveguide-coaxial cable converter, coaxial cable, attenuators and amplifiers. The detector module was fabricated using microwave integrated circuit (MIC) technology by Kyushu University group. The sensitivity and linearity of the system was confirmed.

[D4]: *"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 (LH) current drive and plasma current start-up experiments on TST-2 was continued by collaboration between the Univ. of Tokyo and the NIFS RF group during this fiscal year. Testing and adjustments of the 200 MHz transmitters transferred from JAEA are now nearly completed. The combline antenna used previously on the JFT-2M tokamak was transferred from JAEA to the Univ. of Tokyo, and is being modified for use on TST-2. Plasma current ramp-up experiments using LH are planned to commence in 2009.

[D5]: *"Kinetic effect of beam ion in a high-beta region by equivalent NBI technique," by Asai T. et al.*

This collaboration was carried out between NIFS and The Nihon Univ. on the study of the kinetic effect of high energy particles on MHD characteristics of Field Reversed Configuration plasma which has an extremely high beta value. As possible effect of injected background particles, delay of an on-set time of rotational instability has been observed. Also, prolonged particle confinement time and flux decay time have been indicated. Self spin-up reaching Alfvenic velocity has also been investigated experimentally.

[D6]: *"Development of high power sub-terahertz pulse gyrotron," by Saito T. et al.*

This collaboration was carried out between NIFS and the Univ. of Fukui on the development of a high power sub terahertz pulse gyrotron for application to collective Thomson scattering from a high density plasma in the Large Helical Device. As a step to the final goal, a second harmonic gyrotron using a newly designed electron gun was fabricated aiming at 50 kW at around 400 GHz. Oscillation modes were carefully selected from the view point of mode separation. The maximum power so far obtained is about 50 kW for TE6,5 mode (350 GHz) and about 40 kW for TE8,5 mode (390 GHz). These powers are new records obtained in this frequency range at second harmonic resonance.

[D7]: *"Development of External Control Knob for Improved Confinement Mode in TU-Heliac," by Kitajima S. et al.*

This research program is to study the effect of magnetic island on the transport using TU-Heliac of Tohoku Univ. TU-Heliac has advantages that (1) the position of a rational surface is changeable by selecting the ratio of coil currents, (2) the island formation can be controlled by external perturbation field coils, (3) a radial electric field and particle transport can be controlled by the electrode biasing. To check experimentally the effect of the external perturbation field, we measured the floating potential by a Langmuir probe (high speed triple probe). Power spectrum have the maximum around the m = 3 magnetic island, which reflects the external perturbation correctly. We also measured phase differences in floating potential signal of two probes which set on a same meridian plane. The results agreed well with the expected value π in the c/cw rotation (ion-diamag), but the phase difference in the cw rotation (el-diamag) had large error.

[D8]: *"Development of High Power Induction Plasma Device for PSI Studies using MOSFET Inverter," by Uesugi Y. et al.*

This collaboration was carried out on the development of the arbitrary-waveform thermal plasma (AMITP) system using high-power MOSFET inverter power supply for studies of plasma-material interactions. The amplitude of output rf current is controlled to the waveform of externally-given modulation signal by pulse-width modulation (PWM) control. The frequency of the MOSFET inverter is controlled to around 350-450 kHz by a phase-looked-loop (PLL) control to obtain load-impedance matching. The Ar AMITP is generated at the power of 30 kW. The time behavior of Ar atomic line and the excitation temperature was studied.

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List of reports

P 1. "Control of ion acceleration by RF waves in a fast-flowing plasma," by Ando A. , et al. (Tohoku Univ.).

P 2. "Plasma simulation experiments using versatile highly charged ion sources," by Nakamura N. et al. (The Univ. of Electro-Communications).

D 1. "Development of cesium-free deuterium negative ion source with grid bias method," Fukumasa O. (Yamaguchi Univ.).

D 2. "Analysis of T_c, J_c and H_{c2} properties for low activation superconducting wires," by Hishinuma Y. et al. (NIFS)

D 3. "Measurement of Electron Bernstein Wave Emission from Ultra High Beta Plasmas," by Ono Y. et al. (Univ. of Tokyo)

D 4. "Heating and current drive experiments on the TST-2 Spherical Tokamak," Takase, Y. (Univ. Tokyo).

D 5. "Kinetic effect of beam ion in a high-beta region by equivalent NBI technique," by Asai T. et al. (Nihon Univ.)

D 6. "Development of high power sub-terahertz pulse gyrotron," by Saito T. et al. (Univ. Fukui)

D 7. "Development of External Control Knob for Improved Confinement Mode in TU-Heliac," by Kitajima S. et al. (Tohoku Univ.)

D 8. "Development of High Power Induction Plasma Device for PSI Studies using MOSFET Inverter," by Uesugi Y. et al. (Kanazawa Univ)