4. Basic, Applied and Innovative Researches

Research reports compiled in this section are mostly for the scientific products of the general collaboration program of NIFS. As an inter-university research institute, NIFS is responsible for promoting basic researches of fusion science and plasma science in Japanese universities. Research activities reported in this section are real bases of NIFS as well as fusion researches in the flagship experimental facility LHD. As many as 29 reports are presented for the year of 2015 and it is important that the number of reports are gradually increasing.

HYPER-I device is one of major plasma experimental devices in NIFS for the collaboration researches of the basic plasma science. Plasmas are produced by the ECR discharges using the right-handed circularly polarized 2.45 GHz microwave. The main topic on this device in 2015 was the development of novel laser diagnostics based on the optical vortex. It uses a Laguerre-Gaussian beam instead of a conventional plain wave. This new diagnostics can detect the atomic flow in perpendicular to the laser propagation vector. The laser absorption spectroscopy experiment in HYPER-I plasma showed dependence of the frequency shift, which agrees to the expected azimuthal Doppler shift of the Lagauerre-Gaussian beam.

Doppler spectroscopy for the ion flow measurement using the laser induced fluorescence (LIF) was successful. This method has an advantage of making little perturbation to target plasmas. Both ion temperature profile and the flow pattern were obtained for the HYPER-I Argon plasmas. On the other hand, the ion flow velocity fluctuation was measured with the conventional Mach probe for studying turbulent plasma helicity. Nonlinear axial flux was estimated from the frequency spectra of the density and velocity. Physics of turbulent transport was also studied using the particle tracing technique in the electroconvection turbulence in a planar liquid crystal cell. The effect of the rotation was investigated.

A progress in the Microwave Computed Tomography (MWCT) was made with a scope of the application to the breast cancer diagnostics without pain nor X-ray radiation exposure to human body. A special microwave receiver DiLDAS (Dielectric Laminated Dipole Antenna with Shield) was developed and a preliminary test was completed. The analyzing software of the microwave signals of the tomography was also developed with the information science approach.

In Tohoku university, a study of formation of electric field in a fast-flowing plasma with diverging magnetic nozzle has been continued. The effect of magnetic Laval nozzle is applied in addition to the simple divergent magnetic field and the increase of the axial flow velocity was obtained. A new concept of plasma window was developed in the collaboration with Hiroshima university using TPD plasmas in NIFS. It utilizes a high gas-plasma viscosity in the cascade arc to suppress a gas flow at the interface between the atmospheric pressure and plasma discharge chamber. In Argon plasmas of TPD device, the steep pressure gradient was created showing the plasma plugging effect for the gas flow.

Precise measurements of emission spectroscopy of multiply charged heavy ions were made using the Compact electron beam ion trap (EBIT) in NIFS. The research is motivated by the development of the light sources in the extreme ultraviolet (EUV) range of frequency for the semiconductor lithography. Highly charged high-Z species of Ga, Ge and Pt were studied with mono-energetic electron beams to excite ions to the precisely defined excitation state. Optimization of the chemical vapor deposition of the synthesis of monolayer graphene was studied. Acetylene gas was used on nickel catalytic substrate. The dependence of H_2 concentration, nickel film thickness and the cooling rate on the properties of graphene was investigated.

In Tokyo university of agriculture and technology, very high-beta plasmas were studied using helicon wave with relatively low magnetic field. A spiral antenna was used to put 5 kW rf power with the frequency range of 3 to 15 MHz. Maximum beta value was 450 %, where the reduction of the magnetic field strength with high-beta plasma was 16 %. The helicon plasma is also a candidate of the thruster for a deep space explorer because it does not have any contact electrode, which has a problem of material damage with high density plasmas. For an intense gas fueling, a supersonic gas puffing was tested in Large Mirror Device. For the measurement of gas pressure profile, a Schultz type ionization gauge was developed. A very high gas pressure profile was successfully measured.

In Nihon university, application of laser plasma discharge was examined to improve the burning efficiency of fuel in the internal-combustion engines. Focused laser is irradiated to a fuel gas to produce an arbitrarily long path of plasma enabling the long distance spark discharge, which does not obey the Paschen's law. In the reconnection experiment with high guide field in the UTST device of Tokyo university, energetic electrons were efficiently produced near the X point region by the reconnection electric field. The structure in the current sheet region was clearly observed by using ultra-fast camera. In addition, a new optical measurement system was fabricated with 20 optical fibers for investigating the fine structure of the current sheet.

Promotion of cooperation among plasma-related interdisciplinary sciences was supported by the general collaboration program of NIFS. Although areas of plasma science and application are expanding, their collaborations between research groups in different universities are not yet sufficient. The NIFS collaboration program is one of key elements for this direction of comprehensive plasma sciences for basic and application researches.

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