4. Basic, Applied and Innovative Researches

This section compiles the research reports for the basic and applied plasma physics as well as the reports for activities in coordination research project which has been reorganized in the fiscal year 2014. The 26 reports compiled in this section are the evidence of the wide scope of the research in the National Institute for Fusion Science (NIFS). Although the main research subject of NIFS should be the fusion research using the LHD facility, variety of the researches conducted in the collaboration of NIFS should be the seed for the new innovative research program of NIFS after LHD experiment.

For the basic plasma experiment, HYPER-I device has been operated for 19 years since 1996. The plasmas are produced by the CW microwave of 2.45 GHz with 80 kW power. Recent research topics in this device are the spontaneous flow pattern formation of plasmas and the intermittent phenomena. Development of new diagnostics of plasmas is also the important role of this experiments. A plasma flow diagnostics using the advanced laser technology of optical vortex, which is a rapidly growing topic of laser physics, is highlighted. In the experiment using the liquid crystal fluid, the turbulent state is produced by applying high voltage on the electrodes sandwiching the crystal liquid. The effect of the rotation, physical meaning of which is the application of the axial vector field, was investigated in the measurements of the wave number spectra of turbulence.

The Microwave Imaging Reflectometry (MIR) diagnostics has been developed for the LHD experiment incorporating many innovative microwave technologies and the density fluctuations were successfully measured. Now this technology is applied to the breast cancer diagnostics. The microwave source is scanned in the direction of illumination to the target and in its frequency. The microwave receiving antennae are set for the spatial resolution. A new Dielectric Laminated Dipole Antenna (DLDA) was designed to fit the small size antenna array. The development of data processing software was also made for three microwave imaging problems: 1) CT type diffraction tomography, 2) microwave imaging reflectometry and 3) synthetic aperture imaging.

The development of manufacturing process of cryogenic target for inertial confinement fusion has been continued for the collaboration with the institute for laser engineering in Osaka university. In order to make a uniform fuel layer of target for the fast ignition experiment, the temperature control of special cone, which guides the high intensity laser light onto the compressed target, was necessary. In addition, the infra-red irradiation is applied for improving the uniformity of layer by raising the combined sublimation and re-solidification of solid hydrogen inside the target layer.

Collaborations of basic plasma physics experiment were conducted in universities. In Tohoku university, a fast-flowing plasma is generated by the Magneto-Plasma-Dynamic Arcjet (MPDA) attached to the HITOP device. The magnetic field in the plasma was measured with three-dimensional magnetic probes. The effect of the electromagnetic force was estimated for the experiments of varying the magnetic Laval nozzle strength. In Hiroshima university, the arc jet plasmas were generated using a cathode and copper anode. Spatial variations of electron density was measured with spectroscopy and probes. The profile of density is well explained by the compressible fluid dynamics.

Three experiments were conducted for study of the interaction between the material surface and ion beams. The emission of luminescence from the Er_2O_3 was analyzed in Kobe university for studying the effect of highly charged ion irradiation on the surface. For Tungsten materials, which is becoming more important in the fusion research, the hydrogen ion reflection properties are studied using the proton beam with different charges and the magnetic momentum analyzer for measuring the energy and intensity of reflected ions. The experimental results are reproduced well by the computer simulation with the code ACAT. Another experiment was conducted in Toho university for studying the sputtering and back-sputtering processes with the optical emission spectroscopy of excited atoms from the tungsten metal surface by ion bombardment. Physical properties of tungsten was also studied by measuring the electric resistivity under the He plasma irradiation in Saitama university.

Collaborations of plasma experiment on devices in universities are reported. In RT-1 at Tokyo university, the radial profiles of multi-charged carbon lines were measured and the ratio of ions with different valence was analyzed using the rate equation with contribution of neutrals. In order to understand the profile of ion temperature measured by the Doppler shift spectroscopy, contribution of neutral density profile is also important. Using the Large Mirror Device (LMD) at the Tokyo University of Agriculture and Technology, high frequency spectroscopy of Stark effect was developed for the measurement of electric field near the RF heating antenna. The experiment of the field-reversed configuration (FRC) was conducted with the new facility of FRC Amplification via Translation (FAT) at Nihon university. It was demonstrated that the translated plasmoid becomes a quiescent FRC without disruption.

For the application to the high energy laser system, a new design of Faraday rotator was developed for the optical isolator, which is necessary element to avoid the damage of the system. The terbium gallium garnet (TGG) is the most promising candidate for the material of the rotator. The thermal expansion and thermo-optic coefficient are investigated.

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