4. Basic Research and Development

HYPER-I (High Density Plasma Experiment - I) is the largest experimental device in the basic research and development activities in NIFS. Number of research activities are conducted in this device for basic plasma physics research fields. A report on the next page summarizes experimental results from these researches.

Plasma production with high gas pressure (0.1 - 1.4 atmosphere) was studied in two experiments. First one used 60 MHz VHF wave for hydrogen gas. The composition rate of positive ions (H^+, H_2^+, H_3^+) were measured for different gas pressures and the production of negative ions (H^-) was confirmed by the Langmuir probe measurements. The second one used arc discharges of 200A current with 1 to 1.4 atmospheric pressure of He gas. The electron density was estimated as 2×10^{21} m^{-3} from the Stark broadening of He line emission at 667.8 nm. The flow velocity of arcjet was estimated as 2.7×10^4 m/s from the Doppler shift of the same line which suggests the arc discharge temperature of 6.1 eV.

The structural formation in magnetized plasma was investigated by detailed measurements of magnetic field profiles for the helicon wave plasma production in the straight cylindrical device. Plasmas were produced by 7 MHz RF wave and their axial length was controlled with the movable SUS termination plate. Typical plasma density and temperature are 10^{18} - 10^{19} m^{-3} and 3 - 5 eV. Radial profiles of RF magnetic field (B_z component; z along the device axis) vary sensitively with the magnetic field strength and the RF antenna turns. The axial mode numbers are directly controlled by changing the plasma axial length by moving the termination plate.

Theoretical work has been continued for the neoclassical transport calculation in helical devices. This research started from the theoretical work related to the innovative physics design of advanced stellarator CHS-qa. This year, the modeling of the transport coefficient calculation was extended to plasmas with density and temperature gradients. Particle diffusion coefficients for both protons and fully ionized neon were calculated with the electric field effects for the modeling of impurity profile measurement data especially focused on the impurity hole in the super dense core (SDC) plasmas in LHD. In high density region, deviations from the density-proportional scaling is caused by the collisionless detrapping/retrapping effects due to the strong radial electric field.

In the development of compact microwave ion source for a beam probe plasma diagnostics, a new design of ion source using 14 GHz microwave was made. This frequency was chosen instead of previous design of 2.45 GHz in order to reduce the size of ion source as small as 8 cm diameter and 15 cm long. The magnetic field inside the source is created by the light weight permanent magnet assembly. Three different magnetic field configurations were designed for the experimental performance comparison: multicusp geometry, field free type with dielectric wall and a dielectric microwave inlet in a linear magnetic field.

Intensity distributions of multiplet lines in carbon-like oxygen ion have been studied using TPD-II device (Test Plasma by Direct current discharge II) for the purpose of understanding the anomalous spectral line intensity ratio of the triplet transition in carbon-like oxygen ion observed in the experiment. Such work is important since the parameter dependence of the spectral line intensity ratio became recently a useful tool for the plasma diagnostics.

Finally basic physical mechanisms in the plasma and material surface interaction were studied both in experiments and model calculations. The reflection characteristics of 1 keV protons was studied for carbon surfaces with different surface structures. The energy of 1 keV was selected as a low energy particle flux in fusion devices in order to study particle reflection mechanism without making strong sputtering. Four types of carbon surface were studied: carbon nanotube, carbon nanowall, graphite sheet and highly-oriented pyro-graphite. A clear difference was found in the characteristics of reflected ions between the vertically- oriented and horizontally-oriented systems. For the simulation study, two-dimensional fractal surface model was incorporated into the ACAT code. Fractal demension of D = 2.3 was employed to simulate the surface structure of highly-oriented pyro-graphite, which gave results closer to the measured data in the experiments.

(Okamura, S.)