4. Basic Research and Development

In the basic research and development activities in NIFS, a series of experimental studies using HIPER-I device is a largest product. Their physics interests are focused on the plasma flow and structure formation. In order to make the precise measurements of the flow, various efforts of improving the LIF (laser induced fluorescence) diagnostics have been made.

For the experiment of anti-E×B vortices, where the plasma rotates to the opposite direction of E×B drift, a strong interactions between neutrals and ions are supposed to play an important role. Precise measurements of neutral flows are essential to understand the physical mechanism. Two fundamental efforts have been made for LIF diagnostics in order to measure a very small Doppler shift corresponding to the slow neutral (Ar I) flow speed in the order of 10 - 100 m/sec. An absolute calibration of the laser wavelength was made using a Doppler free spectrum obtained by the saturated absorption spectroscopy. The deviation of laser frequency for 20 discharges was 2.6 MHz. Another effort was the reduction of the S/N ratio by an improvement of optics for 5 times larger solid angle of laser light collection and the selection of a high modulation frequency of 100 kHz for the lock-in amplifier. An inward radial flow of neutrals with a maximum velocity of 80 m/sec was measured.

For the experiment of Plasma Hole, which shows a very low plasma density region in the center of rotating cylindrical plasma, a plasma flow velocity profile was measured using LIF diagnostics. Ar II line was used in the pure argon discharge. The measured profile of azimuthal velocity (in a range of 1 km/sec) shows a rigid rotation in the direction of E×B. The radial flow velocity was outward direction, which is opposite from the case of the plasma hole experiment using helium gas.

Two types of probe diagnostics were developed using HIPER-I plasmas. For the face-to-face double probe (FDP), which measures Mach number of ion flows, an improvement on probe head structure was made for making the information of Mach number more correct by preventing the perpendicular ion flow on the probe head. A calibration test of the Gundestrup type probe, which will be installed in the divertor region of LHD plasma, was made using HIPER-I plasmas. Signals from eight openings of graphite electrode at the probe head clearly showed a combination of parallel and perpendicular (E×B) ion flows to the magnetic field.

Visible spectroscopic study for the short-pulse supersonic helium atom beam was made. The Penning-type discharge was applied on the atomic beam and the visible lines of He neutrals and ions were observed. Several investigations on the vortex dynamics in magnetized pure electron plasmas were summarized. Basic experiments of ion mass separation was made with cylindrical plasma discharges using ten concentric circular rings as biased electrodes. The radial profiles of Mach number, floating potential and ion saturation current were measured for Xe discharges with various electrode bias voltage. The Mach number of azimuthal velocity saturates with increasing bias voltage for Xe plasmas while that for Ar plasmas does not.

Experimental and simulation study were made for the control of ion species in hydrogen ECR plasmas. A fluid model simulation was made with full consideration of physical and chemical reactions. Spatial density profiles of all hydrogen species were calculated and the obtained composition ratio was consistent with the measured one with quadrupole mass spectrometer. A simulation study of a plasma torch experiment was made with a scope of understanding the quenching process of high heat flux plasmas at the divertor. A thermofluid model was developed for Ar, CO_2, H_2 plasmas considering 33 particles and 194 reactions. Temperature distribution of plasmas were compared for the chemical equilibrium and non-equilibrium cases.

A plasma-sputter-type negative ion source with RF plasma production was developed for the application to the negative gold ion source used for the LHD heavy ion beam probe. A basic experiment was made with Cu sputtering target in the pure O_2 plasmas. Negative Cu ion and diatomic copper were detected in the extracted beam. A fundamental study of the interactions of neutral particles with the material surfaces was made using the magnetic momentum analyzer and the time-of-flight analyzer. (Okamura, S.)