5. Basic, Applied and Innovative Researches

This section collects the reports of the NIFS collaboration researches in the basic plasma physics and the plasma physics application including researches in the innovating concepts. An organized collaborations were made for the linear plasma experimental device called HYPER-I, which has 2 m long plasma produced by 2.45 GHz microwave. Seven research reports were summarized in the next page. The spontaneous emissions of intermittent high-energy electron fluxes were observed and their spatial distribution was measured by the wire-grid probe. The flow measurement using the laser induced fluorescence (LIF) has been developed intensively on the HYPER-I and the recent achievements are reported. Important activities in the HYPER-I collaboration are the developments of various diagnostics for basic plasma researches. Progresses of these collaborations are reported.

Two-dimensional maximum entropy method (MEM) with polar coordinates was applied in the analysis of the spatial distribution of electron density fluctuations measured for the H mode transition in CHS experiments. It is clarified that there are plasma layers near the last closed magnetic surface, where the flow velocity largely changes to the opposite direction. For the diagnostics of velocity distribution functions of ions and neutrals in basic plasma experiments, a new LIF method is proposed consisting of excitation and diagnostic lasers. To produce the excited atoms, the non-resonant interaction of femtosecond laser pulse is used. The system becomes robust against the changes in experimental conditions and the optics is simple and tractable.

A shock cell having a rotational structure was found in the Helium arc plasmas with a supersonic nozzle. A two dimensional spatial image of the monochromatic emission of He I was obtained. The shock wave in the arcjet plasma is generated by the collision of plasmas and neutrals in the expansion section, similar to the behavior observed in compressible supersonic gas flow. The production and control of a fast-flowing plasma are of growing significance for developing advanced electric propulsion systems. The control of supersonic and super-Alfvénic flow was investigated using a magnetic nozzle in the HITOP device. The exhausted plasma flow was measured by a pendulum type thrust target. It was found that the plasma flow can be controlled by magnetic nozzle as well as discharge current.

In order to study the processes of productions of carbon dusts by an agglomeration of sub-micron size particles, an experiment was prepared to measure the infrared absorption spectroscopy of hydro-carbon molecules. Another collaboration is for the study of the particle reflection from the carbon surfaces. The reflection rate of hydrogen ions from the vertically-aligned carbon nano-tubes was measured for different thickness of tubes and the incident angles.

We have two reports of collaborations in the imaging science. The first one is the development of numerical technique for the image reconstruction of large size. Advanced study on the missing observation problem is needed. Some methods of fast iterative solver using the Krylov subspace were examined on 2D numerical phantoms in relation to the multi-slice scan of the whole specimen. Compared to the method of conjugate gradient, these methods show good stability of convergence. The second one is for the development of the breast cancer diagnostics. On the basis of experiences in the construction of three-dimensional image analysis technique for the microwave imaging reflectometer and the electron cyclotron emission measurement in LHD, a new diffraction microwave imaging system was developed for the purpose of high-resolution breast cancer diagnostics. The imaging system is expected to have high capability of getting information on the shapes of tumors, which are less than 5 mm in diameter at the early stage of cancer.

In the collaboration with the Hinode project team in the National Astronomical Observatory of Japan, a laboratory experiment to simulate the convective zone in the sun has been started. The electrohydrodynamics convection is produced in the liquid crystal by applying a voltage. A wide-range zoom scope and a polarization scope were prepared for this experiment, which enable us to see the pattern formation in the turbulence. The convective cell becomes smaller as increasing bias voltage and turbulence develops with higher voltage.

In the relation with the tungsten wall in the ITER, two collaboration researches were made. The first one is to investigate the kinetic energy of tungsten atoms sputtered from the wall surface. A Kr^+ ion beam was used to bombard the tungsten surface and the mean velocity of excited tungsten atoms was measured by observing ion-beam induced light emission. It was found that the tungsten energy is almost constant for the Kr energy in the range of 30 to 60 keV. The second one is for the cross section measurement of charge transfer by slow tungsten ions in collisions with hydrocarbon molecules. The extraction of tungsten ions was successful from the electron impact ion source. The improvement of the experimental system is required for getting higher mass resolution of the Wien filter. A cylindrical type electrostatic energy analyzer has been constructed and installed between the Wien filter and the ion source.

Finally a report of collaboration for establishing the linkage of scientific research fields on plasma physics was presented. A committee of the division of plasma physics in the Physical Society of Japan has communicated with other societies related to plasma physics and have been discussed on the policy and plan to promote plasma physics and nuclear fusion researches. In November 2011, the Plasma Conference 2011 was held in Kanazawa city,where 1090 participants attended and discussed about the future collaborations in the field of plasma science.

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