3. CHS Experiments

It has passed almost four years since the operation of CHS experiment was stopped in 2006. The activities of data analysis study have been actively continued and the results were published in many papers of various academic journals. However the number of published paper has been decreasing as the analysis work was advanced. Therefore it was decided that the cooperation work of CHS data analysis would be merged in the category of Basic Research and Development from the fiscal year of 2010. So the 2009 annual report is the final issue where the CHS data analysis results are categorized in the single chapter.

First report describes about great progresses in the data analysis of fluctuation spectrum measurements using the laser imaging method (LIM). This diagnostics were applied to the density fluctuation measurements for the discharge with the L-H transition of the edge transport barrier in CHS. With the reasonable assumption that the wave number vector of the density fluctuation is almost perpendicular to the local magnetic field line, the measurements were made with 1-dimensional detector array rotated shot by shot to find out the direction (angle) of the fluctuation wave number. Taking all data from several shots with different settings of the angle of the detector array, the Fourier analysis was made to obtain the profile of wave spectra on the plane of the wave number and the wave propagation angle. After struggling many years with the low resolution of the angle of wave number, a new method of the maximum entropy method was adopted for the analysis tool, which gave a dramatically improved resolution in the direction (angle) of the wave number vector. This improvement in angle resolution gives the better identification of the location of the density fluctuation in the H-mode plasmas in CHS.

The next report shows also the analysis of fluctuation measurement data for the CHS H-mode experiments. A specially designed hybrid probe was installed in CHS experiment for the direct local measurements of fluctuations (density, potential and magnetic), It does not have a dynamic sweeping mechanism. Instead, the hardware structure is designed tough (with cooling channels) against the damage from the high temperature plasmas at a plasma edge. Although the disturbance of the probe on the plasma is not negligible, there were many experimental situations that the physically useful data were obtained in the selected conditions of discharges and carefully selected probe positions. Time evolutions of the turbulent Reynolds stress (RS) were analyzed for the H-mode discharges and the signal timings were compared among the H-alpha monitor signal, local potential measurement and RS signals. It was found that the RS signal showed a sharp increase before the L-H transition timing determined from the H-alpha signal drop. It was also measured that the RS has a strong radial gradient, which could drive a poloidal shear flow at the timing just before the transition. The local potential measurement shows a sharp dip at the same timing of the RS increase.

The experiment of non-neutral plasmas was one of pioneering subjects of CHS experiments conducted by the leadership of collaborators. It is now continued on Heliotron J device in Kyoto University. An electron gun was used to fill up the magnetic surfaces of CHS with high-energy electrons (order of keV). The density and the potential profiles were measured and the non-symmetry of the profiles was confirmed, which means that the potential is not uniform on the magnetic surfaces. Such a special conditions different from the normal high temperature plasmas is an interesting feature of non-neutral plasmas. The orbits of high-energy electrons are calculated including the potential effect produced by the injected electrons. The results are characteristic for the non-neutral electron plasmas and give consistent image of electron trapping observed in the experiments.

For analyses of plasma rotations especially that measured at the neoclassical internal transport barrier (N-ITB) in CHS, a systematic and fast calculation method of the resonant viscosity is developed. In both of tokamak and stellarator studies, this effect has been considered to be important often in the edge transport barrier physics. In heliotron configurations, however, the study of the N-ITB manifested an importance of the resonant effect for the impurity ions in inner regions. The newly derived formula is now applied to a test calculation of impure plasmas in LHD configurations.

Finally the magnetic configurations used in CHS experiments were analyzed based on the Fourier modes of the boundary shape (last closed magnetic surface). In CHS and LHD, the confinement properties of magnetic configurations are largely changed by the shift of magnetic axis with the vertical field control. So the characteristic of configuration is labeled practically with the magnetic axis positions. It is obvious that the change of confinement property is not produced by either the position of the magnetic axis or the radial position of the torus. It is configured by the change of boundary shape. The Fourier components are compared for typical selections of the magnetic configurations and it was found that the change of confinement properties are controlled by the amplitude of the helical axis component, namely, the inclusion of the non-planar axis structure in the planar axis stellarator CHS. We usually classify various types of stellarator grouping into the planar axis and non-planar axis devices. However such a classification is not physically useful because the most essential configuration control of non-planar axis stellarator CHS (and LHD) is the control of the helical axis component. (Okamura, S.)