3. CHS Experiments

After CHS experiment was shut down in 2006, scientific works of data analysis have been continued for the documentation of CHS experimental results. Keywords for the important research topics are zonal flow, turbulence, HIBP(heavy ion beam probe), fluctuation measurements, H-mode, reheat mode, EBW heating, non-neutral plasma.

Physics of zonal flow and turbulence has been studied in CHS with a powerful diagnostic tool of the twin HIBP systems. A direct identification of low frequency zonal flow was clearly given from the CHS experiment a couple years ago, and a more advanced topic of the linkage between the zonal flow and the turbulence has been worked out in the last year. By using an advanced mathematical procedure of wavelet analysis, it was clarified that the turbulence power was strongly related to the zonal flow amplitude.

Two other topics from HIBP diagnostics are studied. The evolution of the radial profiles of the potential fluctuation and its phase were analyzed within one cycle of the bursts of the beam excited MHD instability. A possibility of the excitation of zonal flow in the beam driven instability is suggested. For ECH plasma, density fluctuations were analyzed during the density ramp-up phase and at the radiation collapse. It is noted that the low frequency density fluctuation rapidly increases just before the collapse.

New information of the density fluctuation was given from the HCN laser scattering measurements. It can distinguish the propagation direction by using the heterodyne technique. Density fluctuation at the plasma edge was detected for the plasma of the average density up to 6×10^{19} m^{-3}. While turbulent spectrum up to 200 kHz was measured for the inward direction of radially propagating fluctuation, sharp fluctuation peaks with harmonic frequencies up to fifth components were detected for the outward radial direction. The frequencies of such a harmonic spectrum have a correlation of averaged temperature.

Data analysis for another density fluctuation measurements using YAG imaging method has made a progress to show the fluctuation power spectra in the two dimensional wave number plane (k_x for the major radius direction and k_y for the toroidal direction). A suppression of the fluctuation level was confirmed for the transport barrier formation.

New methods for the analysis of fluctuation data were applied to the probe array signals for the scrape-off layer plasmas. Probability distribution function (PDF) was calculated for the signal amplitude difference with an arbitrary time delay and the characteristic timescale of the fluctuation was discussed. Data analysis was made also in terms of multi-fractal formalism.

Local density measurements by the beam emission spectroscopy (BES) for the H-mode plasmas in CHS have shown various important information of the edge density profile variation (steepening) with the edge transform barrier (ETB) formation and the fluctuation spectrum showing harmonic oscillations (EHO). There was the unsolved problem of the inconsistency between the mode numbers of these oscillations and the rotational transform of the magnetic surface at the edge. Further analysis of the EHO signal combined with magnetic probe signals reveals that there are two different modes at the edge and the core of the plasma with very close fundamental frequencies.

Reheat mode is very effective for the confinement improvement of high-density plasmas in CHS. Variations of the edge electron pressure profiles were analyzed for the high-density reheat H-mode discharges and three times increase of the pressure gradient was confirmed in the YAG Thomson profiles. Very strong reduction of density fluctuations was also observed in the reheat H-mode in the YAG laser phase contrast interferometer measurements. Impurity behaviors were discussed for the reheat mode plasmas based on three different diagnostics for the radiation and impurity lines.

Advanced wave heating physics has been studied for electron Bernstein wave and whistler wave heating. Electron heating was successful for the plasma with more than twice larger density of cut-off density with so-called O-X-B heating scenario. Polarization of the wave was controlled and the left-hand circular wave gave the most effective heating. For the experiment of another electron Bernstein heating scenario, the slow X-B process, new movable microwave mirror was installed in the vacuum chamber in order to allow the access window for this wave launching scheme. After adjusting the wave launching angle with mirror, effective electron heating was confirmed with clear increase of central electron temperature. Whistler wave heating was studied for low magnetic field with assistant low power microwave.

Unique diagnostics in CHS have made progresses in the density reconstruction analysis for the two dimensional edge density measurement by lithium beam probe and calibration of fast ion flux measurement using NBI for the hybrid directional probe (HDP). Study of neutral particle dynamics related with Hα emission diagnostics has also made a progress to calculate model distribution of neutral particles on the wall with KMAGN field line tracing code. Further analysis of data was made for the innovative experiment of non-neutral plasma confinement in CHS. From the analysis of the probe characteristic curve, up-down non-symmetry of plasma dynamics was confirmed. Data management for all experiment data obtained in CHS has been maintained and continuous efforts for improving accessibility of the data from scientists was made.

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