Visualization of the 2D structure of the fluctuaitons in fusion plasmas

Satoshi Ohdachi[1]

[1] NIFS

In magnetically confined fusion devices, the plasma is confined by the nested magnetic surfaces; the pressure of the plasma is held by the magnetic field. In order to realize economical fusion reactors, reduction of the strength of the magnetic field is required. However, when the ratio (beta) of the plasma pressure to the magnetic pressure decreases, various kinds of the instabilities evolves and they lead to the deterioration of confinement. It is thus important to study how the instabilities evolve and how they affect transport. For example, in the sawtooth activities observed in Tokamak devices, the core plasma with the high electron temperature and the density is expelled repeatedly. This heat flux are caused by the reconnection of the magnetic field on a magnetic surface having a rational safety factor (the number of times a magnetic field line goes around a torus “the long way” (toroidally) for each time around “the short way” (poloidally)) q = 1. The magnetic surface is deformed and shifted by the MHD instabilities on this rational surface. The reconnection of the magnetic field lines, which is driven by this shift, changes the topology of the field lines; the volume around the magnetic axis is expelled and a new axis is formed. In order to study this kind of complicated non-linear process, we should measure 3D structure of the perturbations generated in the plasma. However, if we consider that the reconnection occurs along the field lines, 2D structure gives sufficient information, though it is not easy to build 2D fluctuation diagnostics for fusion plasmas.

We have been developing a tangentially viewing soft X-ray camera system. This system basically is a pinhole camera having a fast framing video camera equipped with scintillator screen (CsI) for the soft X-ray radiation. It can record tangential image of the plasma with 100 x 100 resolutions. The maximum framing rate is 20 kHz. Since the perturbations tend to have the equal phase along the magnetic field lines, tangential view, which is almost parallel to the magnetic field lines, give a good opportunity to visualize the 2D structure of the perturbations.

We have found clear deformation of the flux surface in the sawtooth events found in the Large Helical Device (LHD) by this camera. Deformation with poloidal mode number m = 3 from the interchange motion has been seen. Enhanced transport due to the reconnection from this deformation are observed. It is similar with but different from the sawteeth in tokmaks; it was not accompanied by the topological change of the magnetic field lines. The heat pulse at the event is thereby smaller than those in tokamaks.

In the presentations, we will also show the saweeth phenomena observed in TEXTOR tokamak and compare the spatial structure of LHD. Several dynamic phenomena including ice-pellet induced oscillations will be given. The analyzing method for 2D video image based on singular value decomposition will be also discussed.