§24. Studies of MHD Equilibrium and Stability in Heliotron

Sakakibara, S., Suzuki, Y., Watanabe, K.Y., Yamamoto, S., Nagasaki, K., Okada, H., Sano, F., Mizuuchi, T., Kobayashi, S. (IAE, Kyoto Univ.), Nakamura, Y. (GSES, Kyoto Univ.)

In order to analyze the MHD equilibrium and stability of Heliotron such as LHD and Heliotron J, we try to build a common database including several parameters (e.g. onset time, amplitude and frequency of MHD instability). This database will include a large amount of data obtained at high sampling frequency from multichannel diagnostics. Therefore, new method to analyze the large amount of data is required.

Data mining techniques based on statistics, pattern recognition, artificial intelligence and information technology have been used in the areas of distribution and finance for business, and bio-informatics, astronomy and geology for science. Data mining techniques can extract new information because they are able to automatically pick out patterns in large amounts of high-dimensional data. We applied a data mining technique to analyze the fluctuation signals within a large database in order to identify MHD instability on Heliotron J plasmas. Moreover, the entry of information about MHD instability classifications into a database enables us to exactly and quickly investigates the characteristics of MHD stability through parameter studies. We analyzed 3786 plasma discharges (shot) including all of 14 magnetic probe data. We used 1024 data points which were used for the short time segments (Δt~1ms). The size of database with multiple data points per time interval exceeds 2.5 million data points. Fig. 1 shows nine clusters, which are well defined by the data mining technique using the expectation maximization (EM) algorithm. The frequency of MHD instabilities in each cluster shown in Fig. 1 is in the range of frequencies $f = 20 \sim 150$ kHz which are close to the frequency of shear Alfvén continua. Fig. 2 shows the phase differences between each magnetic probe for each cluster shown in Fig. 1 calculated using the fast Fourier transform (FFT). The plot numbers in Fig. 2 corresponds to those in Fig. 1. The estimated poloidal mode number m for each cluster is indicated in Fig. 2. To investigate why the observed high frequency mode propagates in the different two directions, we searched the magnetic field strength in the database as shown in Fig. 3. As a result of comparison between cluster in Fig. 2 and database of magnetic field strength in Fig. 3, almost all of observed modes propagate in the diamagnetic drift direction of ions. The energetic-ion-driven MHD instabilities propagate in the diamagnetic drift direction of ions. The advantage of data mining technique is that it is easy to investigate the characteristics of the observed MHD instability through the parameter study. Parameter studies using database related to the energetic ion characteristics and plasma parameters such as the energetic ion velocity and electron density showed that the observed MHD instabilities in the nine clusters are energetic-ion-driven MHD instabilities destabilized by the co-flowing energetic ions.

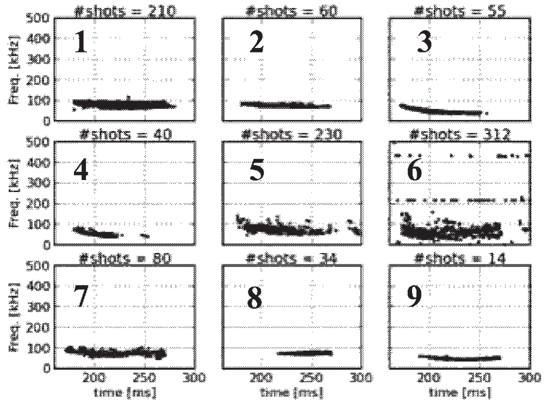

Fig.1. Nine clusters defined in phase space

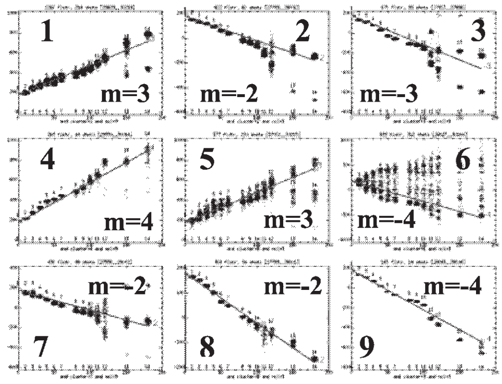

Fig.2. Phase difference of magnetic signals

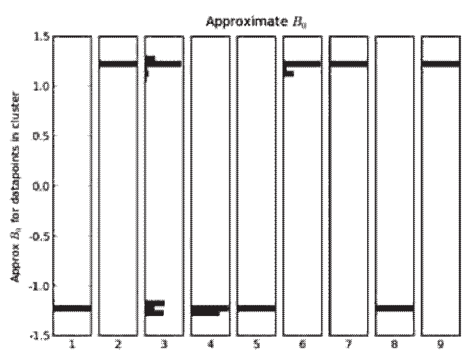

Fig. 3. Magnetic field strength for each cluster