§54. Analysis of MHD Stability Using Data Mining Technique in Helical Plasmas

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The aims of this research collaboration to employ "automated" computer processing, developed on H-1NF (The Australian National University), and Heliotron J (Kyoto Univ.) to MHD data from the Large Helical Device (LHD) at the National Institute of Fusion Science (NIFS) which is the leading international Stellarator/Heliotron device. The purpose is to automate the extraction of wave information such as mode numbers, frequency and polarization obtained from magnetic probe signals to aid in physics interpretation of the LHD experiments, and to create searchable databases to complement those already available (http://egdb.lhd.nifs.ac.jp/shotinfo/). This would enable searching follows:

- The strongest n=1 activity in a given range of magnetic fields (shots etc.). Here n is the toroidal mode number.
- Down frequency chirpings in a given frequency range and shot/magnetic field range.

After successfully upgrading to the new version in late 2010, and visiting LHD for discussions with Drs. Sakakibara of NIFS and Yamamoto of Kyoto Univ., access to time dependent density, NBI power and plasma current data was obtained with the help of Drs. Tanaka and Emoto. Progress in the LHD data mining project this year includes:

1. Include key *time dependent* plasma data so that our new database will have the correct density, beta, and in rotational transform iota for each time and can contain items like n=1 amplitude at highest beta (similar to n_e_max@wp_max in egdb database)
2. Added an approximate amplitude calibration factor, which is necessary to compensate for the normalization that occurs in the singular value decomposition (SVD) step.
3. Included a new analysis method based on cross coherence instead of SVD analysis.
4. Increase the flexibility of the configuration file, which allows very simple change over of signals names, such as occurred in the upgrade of the Aurora 14 analog digital convertor (ADC) to National Instruments (NI) devices.
5. With the above improvements (1,2 and 4), we re-analyzed all the ~ 300 LHD shots in the IEA stellarator working group high performance database DB07_25, as part of a CWGM project.
6. Developed new analysis techniques on the recently installed helical array in H-1NF, which will be tried in LHD. These take advantage of the more constant signal amplitudes inherent in a helical array when compared with a poloidal array of magnetic probes in which the probes are usually at a wider range of distances from the plasma.

The present version of data mining (https://code.h1svr.anu.edu.au/projects/pyfusion) is a complete rewrite to allow much more flexible selection of data sources, a comprehensive configuration file based on the RFC822 standard. This was extended within the RFC822 standard to allow variables so that big changes in configurations can be easily made. One example is changing from local data to remote data – only one word changes in the configuration file. This flexibility is valuable for LHD, where the ADCs were completely replaced at shot 72380, or the channel numbers change such as at shot 26208. This allows comparison over the whole range of LHD shots.

The amplitude of magnetic probe signal is difficult to relate to the amplitude internal to the plasma, without knowing the MHD eigenmode solution for each mode. The new code has an estimate of amplitude which attempts to overcome the effects of normalization (especially when using SVD techniques) and variable attenuation of probes are different distances from the plasma. Frequency chirping (df/dt) for each identified fluctuation structure datum "*flucstruc*" is measured by choosing the nearest available "*flucstruc*" later in time, where the L2 metric for nearness includes difference in phase angles, mode frequency, energy and time, weighted appropriately. The figure shows n=1 and 2 chirping modes that have been successfully classified.

The database is queried with structured query language (SQL) such as select shot_number, freq, amp, df/dt, toroidal mode number n, poloidal mode number m from "*flucstrucs*" where "ne19bar>1 and df/dt < 4 and amp > 0.1 and n between 0 and 3.

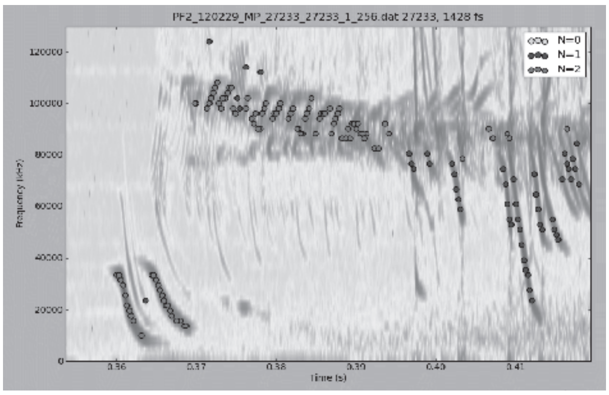

Figure. 1, Down an up chirping modes identified by data mining in a shot from the 2007 CWGM high beta database.