§29. Exploration and Comparison of Physical Mechanisms Related to the Dynamic Evolution of Density Profiles in the Toroidal Confinement Devices

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A microwave reflectometer is now being developed for exploring density fluctuations in Heliotron J. This diagnostic enables to expand the measurement region in plasma core region. Here we report the development status of the reflectometer system using frequency modulation.

Short Time Fourier Transform, (STFT) is generally used for fluctuation analysis. For frequency analysis using Fourier transform, Digital Fourier Transform (DFT) are performed to store the signals as digital data by using ADC. In order to apply the STFT to reflectometer signals, an analysis software, MDR (Marvellous Doppler Reflectometer) has been introduced for Heliotron J, which was developed and utilized at TJ-II in CIEMAT, Spain. MDR runs on a program language, IDL, easily usable through GUI, and it includes spectrum distribution display in each time window, separation of background turbulence and coherent modes by using Center of Gravity (COG). Figure 1 shows an operation display of MDR. The FFT results are seen, and the analysis parameters are possible to be controlled easily.

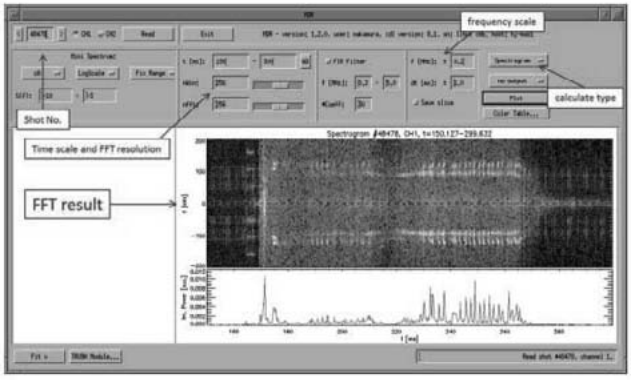

Fig. 1 Example of MDR display

In a test stand of the developed reflectometer, the phase variation appeared to be small in each frequency. In order to investigate the reason, we tested the system by removing the power amplifier. It is found that while the variation is similar in the previous result, the variation range was reduced from 100 deg to 50 deg. This indicate that the power amplifier enhances the phase variation. Since the power amplifier is required to enhance the microwave intensity for high S/N, another type of amplifier may be required.

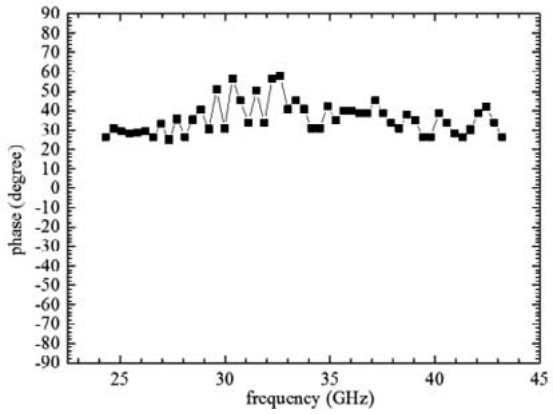

Fig. 2 Output phase against carrier frequency

In order to reduce the phase variation, we have studied the signal intensity and the output phase at each microwave components. The carrier frequency is fixed as 28 GHz. The measurement results indicate that the output phase at modulation components and detection components is dependent on the input carrier wave intensity. As the signal intensity is stronger, the output phase change, approaching a constant value. The performance of phase detector was confirmed to be reasonable. After controlling an attenuator, we have measured the output phase again as shown in Fig. 2. The microwave injected into the PIN switch is set to be -2 dBm. It can be seen that the phase variation is suppressed.

Although an energetic-particle driven MHD instability was observed in a low-density Heliotron J NBI plasmas using the developed microwave reflectometer, the fluctuation signal was masked in a high-density plasmas exceeding the cut-off density probably by noises produced in the reflectometer systems, giving rise to the difficulty of measuring the reliable frequency spectrum. In order to reduce the noise, an improved reflectometer system is being constructed as shown in Fig. 3. Relatively high microwaves of 10dBm will be injected into a Heliotron J plasma without a power amplifier. This system will be applied to the Heliotron J plasma in the next experimental campaign.

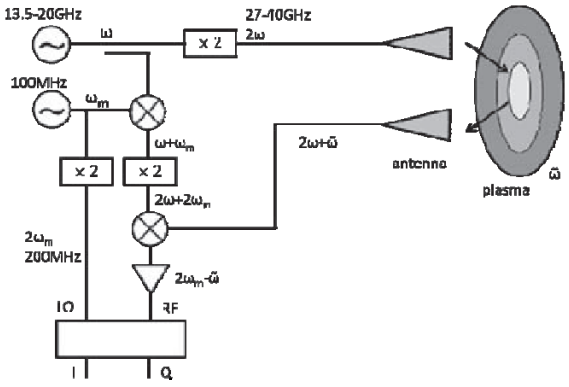

Fig. 3 Improved reflectometer system for density fluctuation measurement