§3. Radial Profile of Poloidal Flow Velocity Measured by Multichannel Frequency-Comb Doppler Reflectometer

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In order to measure the radial profiles of poloidal rotation velocity and fluctuation intensity, a multi-channel Doppler reflectometer has been developed in Large Helical Device (LHD). Doppler reflectometry is a unique technique when used in combination with the back-scattering method and reflectometry. This technique can measure the perpendicular velocity of electron density fluctuations $v_\perp$, the radial electric field E_r, and the perpendicular wave number spectrum $S(k_\perp)$ in magnetically confined plasmas. [1)] For understanding the spatiotemporal structure of these parameters, *simultaneous* multichannel system had been demanded. The developed system is based on a high-frequency, low phase noise comb frequency generator combined with a filter bank and quadrature detection system.

A passive, nonlinear transmission line (NLTL: PSPL model 7112) modulated by a stable synthesizer is used as a source of frequency comb. NLTLs have excellent phase noise performance and generates an array of equally spaced (Δf =0.7 GHz) frequencies with a slow decay in output power. The frequency range of output is initially up to 20 GHz, then, the waves are led to frequency active multiplier in *ka*-band (26-40 GHz). Therefore, simultaneously around 20 frequency components are launched to the plasma. Figure 1 shows the example of frequency spectra obtained in the LHD plasma experiment. Several frequency components are reflected back, simultaneously.

The system is applied to the electrode biasing experiment [2)] for measuring the profile of edge poloidal flow velocity. The poloidal velocity is the key parameter to understand this transition phenomenon experiment. However, the experiment needs to be carried out under the non neutral beam injection and the charge exchange recombination spectroscopy cannot be used. This new diagnostic is just demanded. The magnetic axis position in the vacuum field is R_{ax}=3.75 m, and the magnetic field strength is B_t=1.375 T. The electrode is inserted into around ρ~0.8. When the bias voltage increases, the current at the electrode gradually increases shown in Fig. 2. Then, the current is suddenly dropped at around *t*=4.22 s. It seems to be the transition phenomena. Till *t*= 4.45s this condition is kept and then a back-transition is occurred. During this phenomenon the radial profile of poloidal velocity can be obtained. At first, the poloidal velocity increases near the electrode (r_{eff}~0.46). Just at the transition the fluctuation amplitude decreases in a short time period. During the transition phase, the strong flow region moves to outward with a jump. It is the first observation and more detailed study will be reported.

1) Tokuzawa, T. et al.: Rev. Sci. Instrum. **83** (2012) 10E322.
2) Kitajima, S. et al.: Nucl. Fusion **51** (2011) 083029.

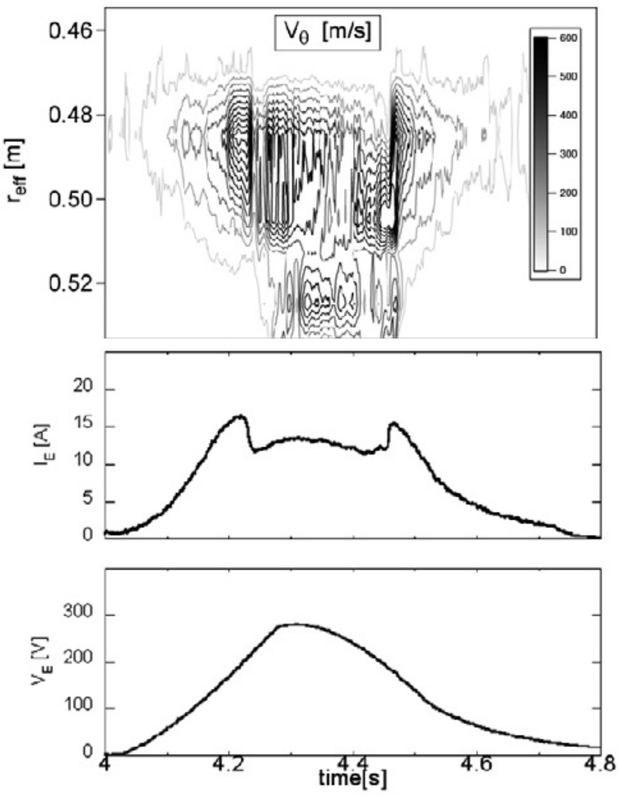

Fig. 2. Temporal behavior of radial profile of poloidal velocity (top: contour plot), current (middle), and bias voltage (bottom).

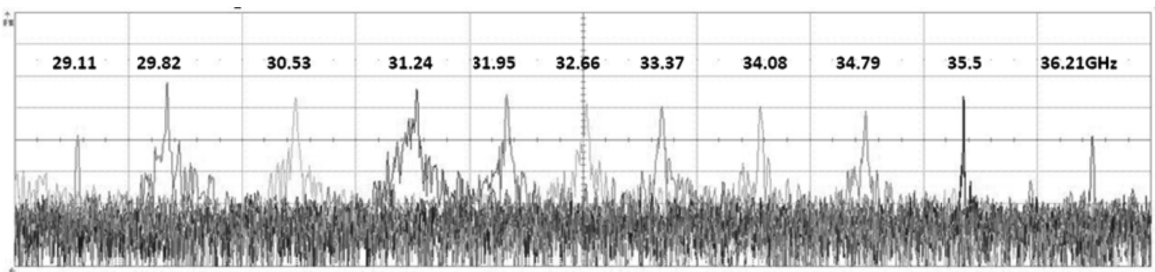

Fig. 1. Example of each frequency comb component reflected from corresponding cut-off layer in a LHD plasma. In this figure, the frequency spectra are over-plotted. The horizontal axis indicates the frequency (1MHz/div) and the vertical axis shows the power (10dB/div).