§6. Developments of Doppler Reflectometer System

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Doppler reflectometry is a unique technique combined with the backscattering method and reflectometry. It 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 magnetized confinement plasmas. Especially, the E_r and its shear are one of the important parameter for the understanding of plasma turbulence and confinement transition phenomena.

The schematic of *ka*-band Doppler reflectometer system is shown in Fig. 1. A microwave synthesizer is used as a source, because its phase noise is low enough to apply the density fluctuation measurements. The utilized frequency range is from 13 to 20 GHz and its output frequency is easily changed by the external GPIB control. For obtaining the complex frequency components and also the phase fluctuation strength, the single side-band (SSB) modulation is utilized. The source output is split into the probe and the reference signal. The probe signal is doubled followed by an active multiplier to bring the launching frequency up to 26-40 GHz (*ka*-band). The microwave launches from the outboard side along inverse the major radius direction on equatorial plane with slightly tilting angle. The polarization of launching wave is selectable on the ordinary mode or extraordinary mode. The returning wave is received and mixed with reference wave. The SSB modulator driven by 220 MHz (f_m) quartz oscillator shifts the frequency of the reference signal for the heterodyne I-Q detection. The suppression levels of image sidebands are less than -20dB in this system. The intermediate frequency (IF) signal is amplified and filtered by band pass filter (BPF) which the pass frequency component is 440±10 MHz. Then, the IF signal and the modulation signal are led to I-Q detection. The output signals of I-Q demodulator, which are described by $A\cos\phi$ and $A\sin\phi$, are acquired by real-time data acquisition system based on a compact PCI digitizer and the sampling rate is usually 1 and/or 10 MHz during the whole plasma discharge. Also, the part of the IF signal is monitored by the spectrum analyzer for checking the frequency shift.

Here, we show a preliminary experimental result of Doppler reflectometer with tilting angle antenna setup in the LHD plasma. At first, we investigate the direction of the back-scattered wave. When a LHD magnetic field direction is changed, the sign of Doppler shift frequency would be changed. Figure 2 show complex frequency spectra obtained in two almost same plasma discharges. The Doppler shifted peak moves to the ion diamagnetic direction in both graphs. The estimated each poloidal velocity is about 5.8 (#99973) and 7.2 km/s (#100263). These values are quite reasonable compared with CXRS.

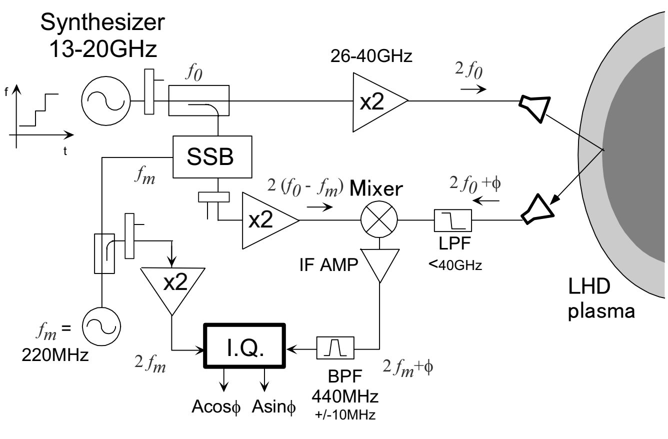

Fig. 1. Schematic of the *ka*-band Doppler reflectometer system.

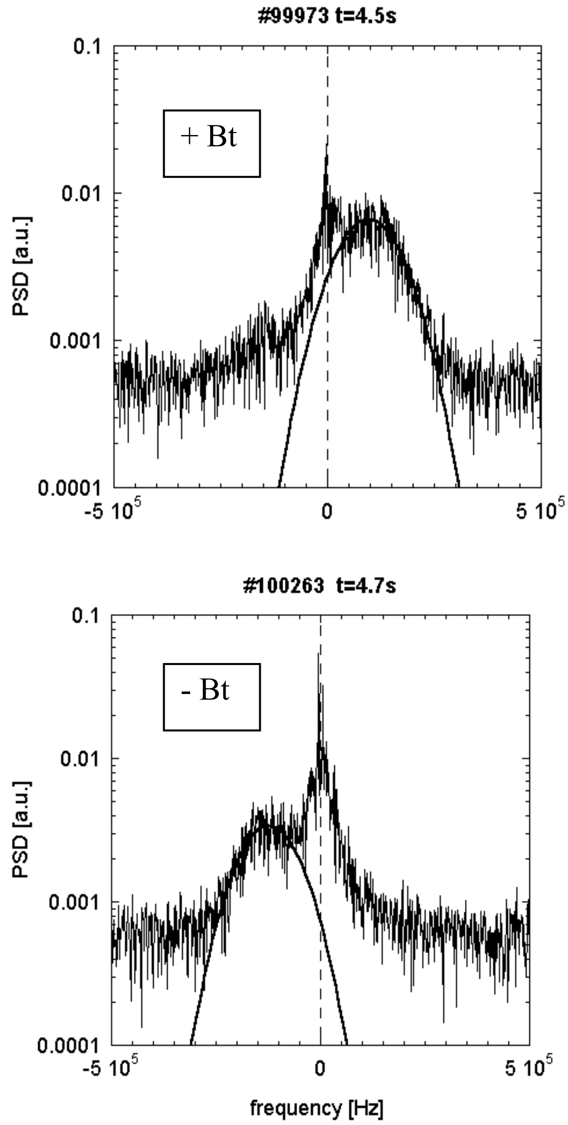

Fig. 2. Complex frequency spectra. Each magnetic field direction is positive (top) and negative (bottom). Solid line shows the Gaussian fitting curve for extracting the Doppler shift.