§10. Measurement of Plasma Rotation by Using Fast Charge Exchange Spectroscopy System

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Charge exchange spectroscopy (CXS) has been conveniently used to measure the profile of ion temperature and plasma rotation velocity and radial electric field. By applying neon gas puff, the charge exchange line of fully ionized Neon, NeX (n=11 to 10, λ=524.9nm) is used in LHD CXS. Improvement of time resolution of the charge exchange spectroscopy is important to study the dynamic behaviors in plasmas such as transitions from ion root to electron root and breathing phenomena.

The time resolution of conventional CXS systems, which had been installed to LHD, is 500 msec. The time resolution is limited by exposure time to accumulate the enough photons not limited by frame rate of CCD. In order to increase time resolution the new charge exchange spectroscopy system with high throughput of light is necessary.

The spectrometer of the fast CXS system consists of camera lenses with F=2.8 and focal length of 400 mm and a 2160 /mm grating. This system has better throughput of lights than that of a conventional CXS system with F=5. Further, the back illuminated CCD with quantum efficiency of 80% is used for the fast CXS system instead of a front illuminated CCD with quantum efficiency of 25% used in the conventional CXS system. By taking account the improvement of throughput of light and the improvement of sensitivity of CCD detector the time resolution is expected to be improved by factor of 9. The 50 fibers with a diameter of 200 μm are arranged at the entrance slit (100μm) of spectrometer. Each fiber leads the light emitted from different radial position in plasma to the spectrometer. The dispersion 0.73 nm/mm at the wavelength of 525 nm which is the charge exchange line of the Neon impurity NeX. The instrumental width is 0.08 nm for the slit width of 100μm. The pixel size, the width and height of the CCD detector are 12μm, 652 pixels and 496 pixels, respectively. Then, the wavelength range of the spectrum image is about 5.7 nm. Since the CCD size is small, there is only 8 channels on the spectrum image of the fast CXS system, while the conventional CXS system has 24 channels.

Figure 2 shows the time evolution of poloidal rotation velocity measured by the fast CXS system with sampling time of 100 msec at two different radial positions near the edge, for the plasma with a magnetic axis of 3.75 m, a magnetic field strength of 1.52 T. Differences of the rotation velocities between two positions indicate an existence of the rotation velocity shear. The solid line shows the line averaged electron density which is measured by an FIR interferometer. The absolute values of the poloidal velocity at the radial position of 4.163 m change from large positive to small positive and the velocity shear decreases as the density is increased. The step like changes of the velocity shear from large (region A in fig. 2) to small (region B in fig. 2) and then to almost zero (region C in fig. 2) are observed.

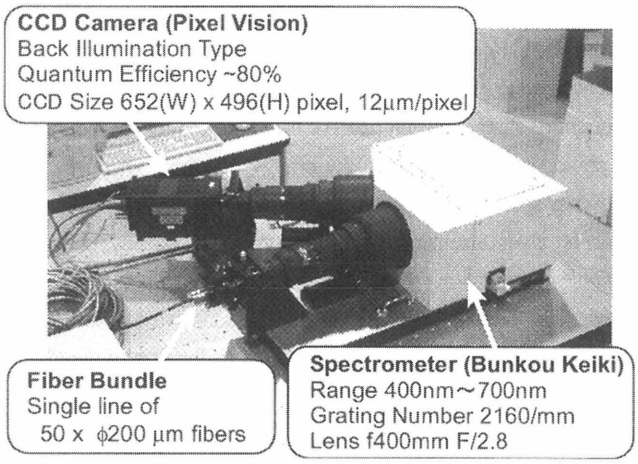

Fig.1. Picture of fast charge exchange spectrometer consisting with back illuminated CCD and F/2.8 camera lenses.

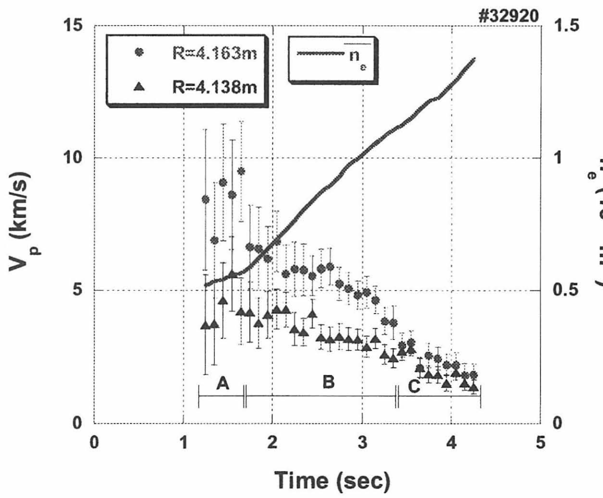

Fig.2. Time evolution of poloidal rotation velocity measured by the fast CXS system (solid circle and solid triangle) and line averaged electron density measured by an FIR interferometer (solid line).