§10. Gas Puff Modulation Experiments on LHD

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In order to understand particle confinement characteristics on LHD, gas puff modulation experiments were done. Particle balance equation for perturbation is described as follows.

$$\frac{\partial^2 \tilde{n}}{\partial r^2}+\left(\frac{1}{r}+\frac{1}{D}\frac{\partial D}{\partial r}-\frac{V}{D}\right)\frac{\partial \tilde{n}}{\partial r}-\left(\frac{V}{rD}+\frac{1}{D}\frac{\partial V}{\partial r}\right)\tilde{n}-i\frac{\omega}{D}\tilde{n}+\frac{\tilde{S}}{D}=0$$

Here, $\tilde{n}$ is modulated electron density, D is Diffusion coefficient, V is convection velocity, and ω is modulation frequency. The solutions of above equation give spatial distributions of amplitude and phase of $\tilde{n}$ for given D, V and ω. D and V in the equations can be determined from the optimized fitting of the amplitudes and phases of the line densities, obtained experimentally[1]. This technique does not need the absolute value determination of particle source, which is experimentally very difficult to obtain. This is because phase of $\tilde{n}$ is determined from the ratio of the real and imaginary part of $\tilde{n}$ and the absolute value of $\tilde{n}$ is not required for the calculation. However, it needs an assumption that the transport does not change during modulation. Figure 1 shows temporal behavior of modulated density, which was measured by 13ch FIR interferoimeter[2]. The line density was modulated sinusoidally by changing the fueling rate of gas puffing. Base density during modulation was kept constant by using feed back control system. The modulation frequency was 1 Hz, and this frequency was determined low enough to modulate the central part of LHD plasma. The amplitude (relative value) and phase did not change experimentally when the modulation level was changed from 4% to 50%, therefore, the particle transport is well assumed to be constant during modulation in this series of experiments. Figure 2 shows spatial distribution of amplitude and phase of $\tilde{n}$. Black colored marks are estimated values obtained by the Fourier correlation analysis for line density, shown in fig.1, white open marks are theoretical values calculated by using D and V shown in figs.3 (a) and (b) by the solid lines. The neoclassical values are also shown in fig.3. The D value obtained experimentally is lager than neoclassical value by one order magnitude. The V value obtained experimentally shows that the convection is directed inward although neoclassical value shows outward convection. Comparison of these particle coefficients under different discharge condition is under going.

1) K.W. Gentl, et al, Plasma Phys. Cont. Fusion **29**, (1987) 1077.

2) K. Kawahata et al, Rev.Sci, Instrum. **70** ,(1999)707.

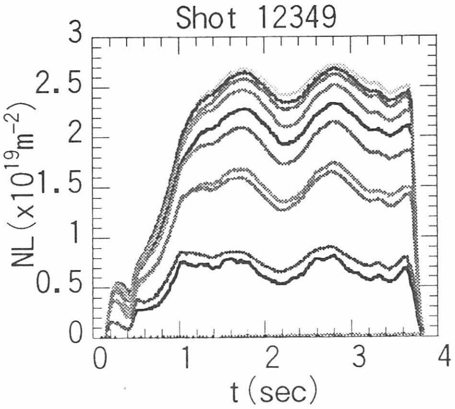

Fig. 1 Modulated line density Rax=3.6m, Bt=2.75T, NBI Co-injection.

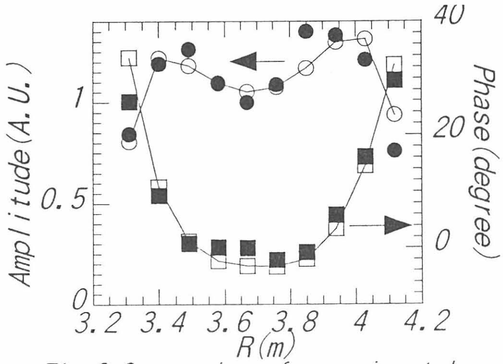

Fig. 2 Comparsion of experimental data (black symbol) and modeled data (white symbol)

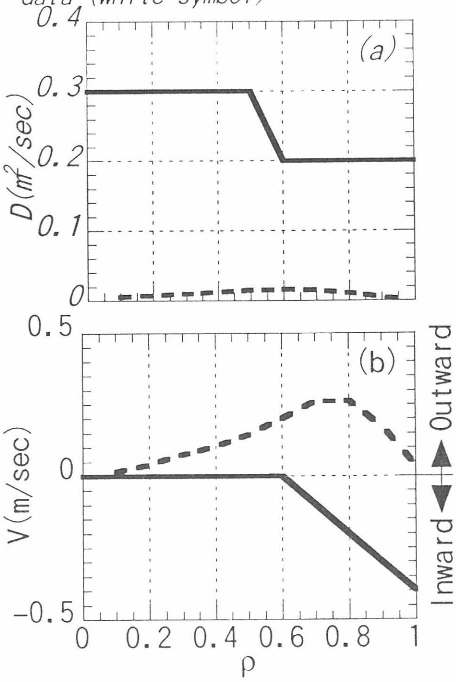

Fig. 3 Comparison of experimental value (plane line) and neoclassical value (dashed line). (a) Diffusion coefficient (b) Convective velocity