§1. Momentum Transport in Ion ITB Plasmas on LHD

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Strongly peaked profile of toroidal rotation is observed in the ion internal transport barrier (ion ITB) plasmas. The direction of toroidal rotation is determined by external drive input due to tangential neutral beam injection (NBI). Figure 1 shows the ion temperature profiles and toroidal velocity profiles of an ion ITB plasmas. In this report, the quantitative analysis of momentum transport is presented. The momentum source and sink are calculated by

$$\Gamma_{\mathrm{M}} = \frac{1}{r}\int r dr\left[F_{\mathrm{ext}} - \frac{\partial}{\partial t}\left(m_{\mathrm{i}} n_{\mathrm{i}} V_{\mathrm{T}}\right) - \mu_{||} m_{\mathrm{i}} n_{\mathrm{i}} V_{\mathrm{T}}\right] \quad (1)$$

where $=F_{\mathrm{ext}}$ and $\nu_{||}$ are external drive force and parallel viscosity coefficient calculated by neoclassical theory, respectively. The external drive force is evaluated by the local momentum deposition of tangentially injected NBI and is calculated by FIT code. The second term corresponds the momentum change in time. The third term corresponds the parallel viscosity, which is a momentum damping effect due to collisions with ripple trapped particles. The radial transport is dominated in the core region, while the neoclassical damping is dominated near the edge. Therefore the rotation characteristics in the core is determined by the transport of momentum. The viscosity (μ) is estimated by Fick's law;

$$\Gamma_{\mathrm{M}} = -\mu \frac{\partial}{\partial r} m_{\mathrm{i}} n_{\mathrm{i}} V_{\mathrm{T}}. \quad (2)$$

The time evolutions of thermal diffusivity and viscosity in the core region of $r_{\mathrm{eff}}/a_{99} = 0.3$ are shown in Fig. 2(a). The viscosity decreases with reduction of the ion thermal diffusivity, and they correlate very well (see Fig. 2(b)). The Prandtl number ($\frac{\mu}{\chi_{\mathrm{i}}}$) is 1.4 ± 0.6, which is almost identical to that obtained in tokamak experiments.

In summary, the momentum transport was quantitatively analyzed for the core plasma with ion ITB. Furthermore, asymmetry of toroidal rotation was also observed between co- and ctr-rotating plasmas, which indicates the existence of intrinsic rotation [1]. The characteristics of intrinsic rotation is a very important issue from the view point of stability of tokamak plasmas. The effects of rotation and rotation shear on the thermal transport are also very important issues in both tokamak and helical plasmas, which will be reported in near future.

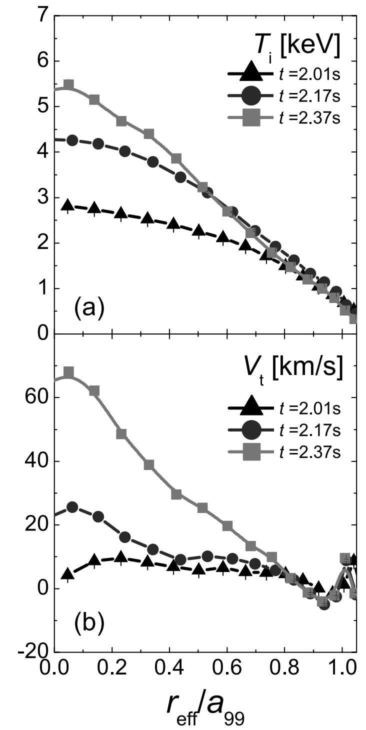

Fig. 1: (a) Ion temperature and (b) toroidal rotation profiles in L-phase (t = 2.01 sec) and ion ITB phase (t = 2.17 and 2.37 sec).

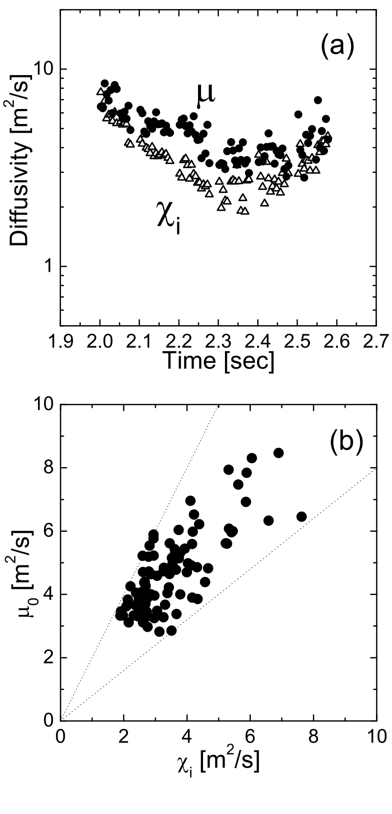

Fig. 2: (a) Time evolution of ion thermal diffusivity and viscosity at $r_{\mathrm{eff}}/a_{99} = 0.3$. (b) The viscosity as a function of ion thermal diffusivity.

1) K. Nagaoka, et al., acceppted to *Nuclear Fusion*.