

§2. Reversal of Intrinsic Torque Associated with the Formation of an Internal Transport Barrier

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A reversal of intrinsic torque is observed during the formation of an internal transport barrier (ITB) in Large Helical Device (LHD). The intrinsic torque evaluated from the disparity of rotation between co-injection and counter-injection changes sign from counter to co direction inside the ITB after the ITB formation. Both the internal transport barrier and the reversal of the intrinsic torque propagates inwards. This experiment demonstrates the sign of non-diffusive term of momentum transport is sensitive to the confinement mode of heat transport. In LHD the formation of an ion ITB is observed during the decay phase of the electron density after the carbon pellet injection¹⁾. The ion ITB is characterized by the peaking of the ion temperature profile (not electron temperature profile) in the core region. In this experiment, the reversal of the intrinsic torque during the formation of the ITB is investigated. There are three phases; increase of ∇T_i with constant thermal diffusivity (Phase I: liner transport), degradation of confinement which is consistent with the critical gradient model (Phase II: critical gradient transport) and simultaneous increase/decrease of ∇T_i inside/outside the ITB region (Phase III: formation of ITB).

Figure 1(a) shows the relation between the sum/difference of the normalized momentum flux and the sum/difference of the velocity gradient. The differences give the relation of the diffusive terms and the sum gives the relation of the non-diffusive term. The relation between the differences shows the diffusive term and the slope gives the viscosity of μ_ϕ . When the sum(co+ctr) exceeds the curve derived from the difference (co-ctr), it indicates intrinsic torque in the ctr- direction. On the other hand, it indicates intrinsic torque in the co- direction when the sum is below the curve. In the region inside the ITB especially near the foot point ($r_{\text{eff}}/a_{99} = 0.55$), the intrinsic torque changes direction from the counter- direction to the co- direction. The velocity gradient increase in the co- direction after the formation of the ITB, which corresponds to the intrinsic torque of $4 \cdot 5 \times 10^5 \text{ m}^2\text{s}^{-2}$ in the co- direction.

The radial profile of the intrinsic torque evaluated from the non-diffusive term of the momentum flux is plotted in Fig. 1(b). Before the ITB formation, the intrinsic torque is in the counter direction in the core ($r_{\text{eff}}/a_{99} < 0.4$), while it is in the co-direction in the outer-region ($r_{\text{eff}}/a_{99} > 0.4$). The intrinsic torques evaluated in the core region change sign from the counter-direction to the co-direction after the formation of the ITB, which clearly shows the strong coupling between the heat transport and the momentum transport. The

intrinsic torque in the L-mode region is in the counter-direction, while it reverses to the co-direction inside the ITB in the ITB plasmas. This experiment shows that the intrinsic rotation is sensitive to the confinement mode (L-mode or ITB) as well as to the electron density.

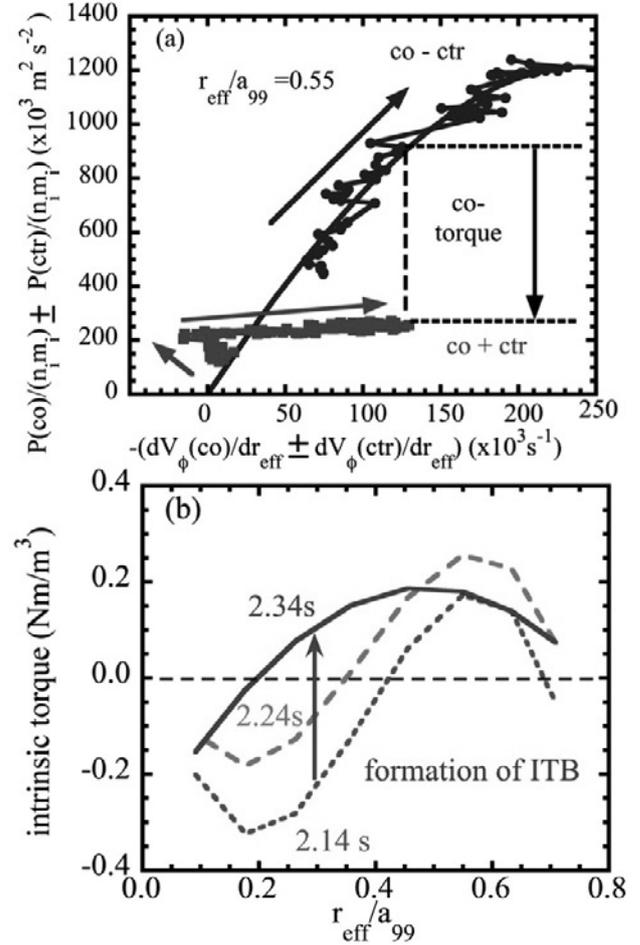


Fig. 1: (a) Sum (co+ctr) and difference (co-ctr) of normalized toroidal torque vs velocity gradient between co-injection and counter-injection discharges at the normalized plasma minor radius of 0.55 and (b) radial profiles of intrinsic torque.

The reversal of the intrinsic torque from the counter- to the co-direction is observed associated with the formation of the ITB. The intrinsic torque is in the counter-direction in Phase II (critical gradient transport), while it reverses to the co-direction in Phase III (after the formation of ITB), while the intrinsic torque is always in the co-direction near the plasma edge. This experiment demonstrates the sign of non-diffusive term of momentum transport is sensitive to the confinement mode of heat transport as well as the collisionality, which has been often observed in the density scan experiment.

1) K.Ida et. al., Nucl. Fusion **49** (2009) 095024