Experimental Progress of Transport Physics in Toroidal Plasmas

Katsumi Ida[1]
[1]*National Institute for Fusion Science, Toki, Gifu 509-5292, Japan*

Recent experimental progress of transport physics in toroidal plasmas is reviewed. The transport characteristics of non-diffusion and non-locality of transport has been recognized to be important in determining radial structures of density, rotation and temperature as well as non-linearity in the flux-gradient relation.

The non-diffusive term of momentum transport appears as a "spontaneous rotation and intrinsic torque"[1,2], while the non-diffusive term of particle transport appears as a "particle pinch and particle exhaust". The sign and magnitude of these non-diffusive terms have been found to be sensitive to the turbulence state, which causes reversal phenomena. In the momentum transport, the spontaneous flow reversal from co- (parallel to plasma current) to counter- (anti-parallel to plasma current) direction and vice versa have been commonly observed associated with a slight change in plasma parameters. In the particle transport, especially in the impurity transport, reversals of convective radial flux from inward to outward are also observed in toroidal plasmas as phenomena of density peaking/flattening and impurity accumulation/exhaust[3].

There is a significant progress on the experimental analysis and theoretical models for non-local transport[4]. In the heat transport, the non-locality of the transport and the departures from linear flux-gradient proportionality have been observed in various devices during the transient phase in the externally perturbed experiment with cooling edge with pellet or gas puff and local heating with modulated electron cyclotron heating (MECH) or in the formation of improved mode such as H-mode and internal transport barrier (ITB). Non-locality of transport has been observed in the response to perturbations, such as a core temperature rise associated with the cooling at edge by pellet injection, sustainment of the core temperature increase for repetitive perturbations by supersonic molecular beam injection (SMBI), strong coupling of transport at different radii as seen in the curvature transition of ITB, and spatial propagation of ITB regions. The turbulence with meso-scale and long correlation, that are strong candidates for causing the non-locality of the transport, have been confirmed experimentally and the coupling between the different turbulence scales has also been identified in various devices

[1] K.Ida and J.Rice, *Nucl. Fusion,* **54** 045001 (2014).
[2] K.Ida et. al., *Phys, Rev. Lett.* **111** 055001 (2013).
[3] K.Ida et. al., *Phys Plasmas* **16** 056111 (2009).
[4] K.Ida, et. al., 24th IAEA-FEC, San Diego, U.S.A. October (2012), OV/3-4.