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3D effects on viscosity and generation of toroidal and poloidal flows in LHD

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Transport is strongly affected by the breaking of toroidal symmetry as seen in the resonant magnetic perturbation experiment in tokamaks, topology bifurcation in reversed field pinches and intrinsically in helical plasmas. In these experiments, the transport parallel to the magnetic field contributes to radial diffusion process, which is recognized as 3D effect on transport. This effect is most significant in the momentum transport, because the plasma flow is sensitive to the change in topology of magnetic field. In this paper, recent experimental results on damping and driving mechanism of plasma flow in 3D topology are discussed. The parallel viscosity is relatively large in the edge region of helical plasmas, but, perpendicular viscosity due to turbulence is dominated in the core region in LHD similar to tokamaks. Significant intrinsic toroidal flow in the co-direction is observed at the mid-radius of the plasma where a large ion temperature gradient (ion ITB) exists, which is driven by turbulence in the nested magnetic surface. The flattening of electron and ion temperature profiles and toroidal flow profile has been observed associated with the topology change from nesting magnetic flux surface to stochastic magnetic field structure. The significant reduction of toroidal flow indicates the increase of viscosity. A large poloidal flow driven by difference of ion and electron parallel transports along the field line was observed in the edge region where the field lines are stochastic and open. The topological change of magnetic field structure contributes to the formation of strong radial electric field shear, which should have strong impact on heat and particle transport at LCFS.