3-D effects on viscosity and flows

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In the axis-symmetry system, toroidal flows are governed by the toroidal momentum transport due to the viscosity between the different magnetic flux surface (perpendicular viscosity), while the poloidal flows is determined by the parallel viscosity in poloidal direction. However, in the helical system or the tokamak with resonant magnetic perturbations (RMP) field, the toroidal viscosity due the non axis-symmetry of the magnetic field causes the damping of toroidal flow[1]. Since both plasma mean flow and zonal flow have been found to contribute to the reduction of transport, the 3D effect on viscosity and mean and zonal flows is recognized to be important. Because of the difference in viscous stress tensor and in the direction of symmetry (axis-symmetry and helical symmetry), the relation between the sign of poloidal flow (or radial electric field, Er) and the sign of toroidal flow is opposite to each other between in axis-symmetry system and in non axis-symmetry system[2]. For example, the edge toroidal rotation in the counter-direction is observed for the plasma with "positive Er" in the non axis-symmetry system, while it is observed for the plasma with "negative Er" in axis-symmetry system[3]. Although the 3D effect gives additional viscosity to the plasma, there are significant zonal flow[4] and spontaneous toroidal flow[5] observed in the 3D system, especially in the plasma with transport barrier, where the large temperature gradients exist. This fact suggests that there is also a 3D effect on the driving mechanism of spontaneous rotation.

References

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