Effect of Plasma Flows on Turbulent Transport and MHD Stability*

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Plasma flows have important effects on tokamak stability and transport on spatial scales ranging from the gyro-orbit scale to the machine size. For example, a key topic of present-day research is the effect of gyro-radius-scale zonal flows on micro-turbulence-driven transport. Somewhat larger scale flows include the changes in sheared E×B flows observed at the L to H transition, the ERS transition and during the spin-up associated with VH–mode. Sheared toroidal flows have been predicted to affect ballooning mode stability while toroidal flows with scales of the system size have been shown experimentally to stabilize the resistive wall mode. Especially in the micro-turbulence cases, the changes in E×B flows are self-generated by the plasma. However, even for the MHD modes, the modes themselves can affect the flows, providing some of the same feedback processes involved in the micro-turbulence cases. The first goal of this talk will be to briefly cover some of the previous results on plasma flows and their effects.

The second goal of this talk is to pose a series of questions to motivate later discussion. These questions include

1. Do the theoretically predicted zonal flows exist? How do we experimentally measure their properties? Do their detailed properties really agree with theory? What are the key predictions that should be tested?
2. What physics governs the average poloidal flows in the plasma? Does the physics described by neoclassical theory play any role here? What additional physics, if any, is needed to understand how the spontaneously generated poloidal rotation arises, for example, at the ERS transition?
3. What physics governs the average toroidal flow in the plasma? Even in cases where the ion thermal diffusivity is neoclassical, the toroidal angular momentum diffusivity is not. What physics must be added to that in neoclassical theory to understand this?
4. What role do MHD modes play in governing the toroidal plasma rotation?

These questions also motivate discussion of diagnostics needed to answer these questions. Key issues here include

1. Developing experimental techniques to measure the zonal flows.
2. Refining the analysis technique needed to compute the gyro-orbit cross section effect on poloidal rotation measurements and then verifying this technique experimentally.
3. Improving techniques to measure MHD modes (e.g. resistive wall modes and Alfvén modes) which can affect rotation.

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