Zonal Flows and Geodesic Acoustic Modes

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Plasma rotation is a cricial element of tokamak physics. Rotation corresponding to low frequency toroidally and poloidally symmetric (m=n=0) perturbations of the electrostatic potential are usually referred as Zonal Flow (ZF). In addition to the m=n=0 perturbation of the electrostatic potential, Geodesic Acostic Modes Modes (GAM) also involve m=1 component induced by plasma compressibility in toroidal geometry (geodesic curvature). GAMs, in the simplest form, represent the linear eigen-modes of poloidal plasma rotation and have finite frequency. Both ZAF and GAMs are of major interest to the problem of anomalous transport and plasma confinement. On one hand, they may be important for the control of the level for drift wave turbulence by providing the energy sink for drift waves. On other hand, they can directly control the level of the anomalous transport by shearing effects. In this talk, ZF and GAM theory is discussed emphasizing the dispersive and electromagnetic effects and relation to the theory of neoclassical rotation in a tokamak.

GAM and neoclassical rotation represent two different regimes of a rotational mode: high frequency rotational regime (GAM) and the low frequency over-damped mode of the neoclassical equilibrium rotation. The transition between these different modes of rotation is discussed.

In tokamak geometry, poloidal rotation is linearly coupled to toroidal rotation. In most general case, several harmonics can be involved. A particular example is a three- dimensional helical structure at the tokamak rational surfaces with the same helicity. Such perturbations may have both electrostatic and magnetic component, leading to large scale flow and magnetic field. Spontaneous generation of such structures will be discussed.