DPP09-2009-000461

Abstract for an Invited Paper
for the DPP09 Meeting of
the American Physical Society

Kinetic theory of geodesic acoustic modes

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Geodesic Acoustic Modes (GAM are linear eigen-modes of poloidal plasma rotation supported by plasma compressibility in toroidal geometry. GAMs are linearly coupled to drift-waves via toroidal side-bands of plasma pressure, can be nonlinearly driven by Reynolds stress from small-scale fluctuations (similar to Zonal Flows) and therefore expected to play an important role in dynamics of drift-wave turbulence. GAMs have also been prominently featured due to their inherent relation to Beta Alfven Eigen-modes (BAE), particularly in plasmas with highly energetic particles Multiple GAM and BEA modes were observed in high-temperature tokamak plasmas and are currently subject of active experimental and theoretical studies. This talk will describe the currents status of GAM/BEA theory. New results will be presented emphasizing the relation of GAM/BAE modes with neoclassical rotation in a tokamak. It is shown that the GAM intrinsically involve anisotropic perturbations of plasma pressure (corresponding to parallel viscosity). Moreover, the GAMs and standard equilibrium (neoclassical) plasma rotation represent two limit cases of poloidal plasma rotation: high frequency rotational mode (GAM) and the low frequency over damped (damping is larger than the real part of the frequency) mode of the neoclassical equilibrium rotation. Most importantly, new regimes of global GAM/BAE modes will be reported. These regimes occurs as a result of the parallel kinetic response of electrons which has not been included previously. It is shown that in certain regimes (corresponding to global modes), the electron response becomes strongly electromagnetic and GAM/BAE modes have significant electromagnetic component in the side-bands (thus it is not of the Alfven type) . Resulting modifications in the mode dispersion and mode damping will be presented and potential consequences for GAM/BAE excitation and electron transport will be discussed.