Wave Momentum, Potential Vorticity Mixing, Symmetry Breaking and The Physics Self-Accelerating Plasma Flows

P.H. Diamond

C.A.S.S. and C.M.T.F.O., University of California, San Diego, La Jolla, CA 92093-0424, USA
Dept. of Physics, KAIST, Daejeon 305-701, Republic of Korea

phd@mamacass.usd.edu; pdiamond@ucsd.edu

Considerable mystery continues to surround the physics of flow self-acceleration in tokamaks and other magnetic confinement devices. In particular, while its clear that flows are generated by a heat flux driven turbulence 'engine' requiring some imposed or spontaneous symmetry breaking, we cannot as yet accurately predict flow profiles, coherence times, or the efficiency of the engine which drives the process. These shortcomings reflect our as yet emerging and incomplete understanding of the fundamental physics.

In this lecture, I will discuss recent progress on critical physics issues in the theory of self-acceleration of zonal, poloidal and toridal flows (i.e. intrinsic rotation)[1]. In particular, I shall discuss:

a.) wave momentum transport: its central role in the self-generation of flows, its relation to radial currents and ambipolarity breaking, the relevant flux-force relationships and the structure of the wave momentum flux in terms of transport "coefficients" and driving gradients.

b.) potential vorticity (PV) mixing: its role as the 'origin of irreversibility' in the turbulent Reynolds force, its basis in microscopic scattering processes and its appearance in kinetic theories of momentum transport in collisionless plasma. The ubiquitous Rhines scale is revisited in relation to the PV mixing processes.

c.) the role of magnetic geometry and boundary interactions in defining global flow structure. In particular, I'll discuss SOL flows and their interaction with core rotation dynamics, especially in the context of the L-H transition, and the role of the H-mode pedestal in the dynamics and scaling of intrinsic toroidal rotation.

The talk concludes with a discussion of unresolved issues and their implications for future MFE experiments.

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