# Shear Flow Generation and Energetics in Electromagnetic Turbulence

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The self-consistent generation of large-scale flows by the rectification of small-scale turbulent fluctuations in magnetically confined plasmas has received strong interest during the last couple of decades. These flows may regulate the turbulence by suppressing the small scale structures and set up transport barriers. It is generally believed that the sheared flows are instrumental in the LH transition now routinely observed in tokamaks and stellerators. In electrostatic turbulence the Reynold stress (Re) is the source of interaction between large-scale flows and small-scale turbulence. This is verified both in recent experiments [1] and several numerical simulations of electrostatic turbulence. Here also a strong correlation between the generations of sheared zonal flows and transport reduction is clearly revealed. In electromagnetic turbulence, which is important for finite beta plasmas as in, e.g., in JET and ITER, an additional source of flow generation must be taken into account: the so-called Maxwell stress (Ma). In tokamak geometries also the geodesic curvature effects, the so-called geodesic acoustic modes (GAM), will interact with the flows in the system. We have examined the zonal flow generation in electromagnetic turbulence in the edge of Tokamak plasmas by means of the Risoe TYR code [2] governing the evolution of drift Alfvén turbulence in a 3D flux tube geometry. Covering a broad range of parameters we have revealed the relative importance of the different driving sources and sinks (Re, Ma, GAMs) for the self-consistent generation of the flows by quantifying the energy transfer into the flows due to each of these effects [3].

The Reynolds stress provides a drive for the flows while the electromagnetic Maxwell stress nearly always is a sink for the flow energy. In the limit high beta limit, where electromagnetic effects and Alfvén dynamics are particularly important, the Maxwell stress is found to cancel the Reynolds stress to a high degree. The GAMs, related to equilibrium pressure profile modifications due to poloidally asymmetric transport, are found to act as sinks as well as driving terms, depending on the parameter regime. For high beta cases the GAMs are the main drive of the flow. This is also reflected in the frequency dependence of the flow, having a peak at the GAM frequency in that regime.

## References

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