Turbulent fluxes and entropy production rate

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The shape of the turbulent transport matrix in magnetized plasmas is of utmost importance for fusion. Particle transport in tokamaks is certainly a good example. In absence of internal fuelling, the density profile is fully determined by the non-diagonal term in the particle flux. Two contributions for non-diagonal terms in the transport matrix have been identified in the literature. The first contribution comes from geometry constraints and is called "curvature" pinch. This contribution involves the gradient of the magnetic field and was in fact introduced in the context of "Turbulence Equi-Partition" (TEP) theory[1,2,3]. The second contribution, expected from thermodynamics, involves thermodynamical forces different from the one that mainly drives the flux (also called off-diagonal terms) [4,5].

This formulation has raised some concern as to its consistency with the second principle of thermodynamics. A way to answer these questions is to calculate the entropy production rate. This procedure allows defining rigorously the thermodynamical forces, including the geometrical effects. Also it gives some insight in the order of magnitude of the various terms. Finally Onsager symmetry provides useful information on the nature of heat pinches when particle pinch terms are known. The aim of this work is to calculate the entropy production rate in the case of an electrostatic turbulence in a tokamak. This is done in the frame of both fluid and kinetic approaches.

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