Mean flow generation via nonlinear polarisation and high fluctuation amplitudes

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Mean (or zonal) flows are of central importance for transport regulation in fusion plasmas [1] and a prominent example of pattern formation and self-organisation in nature [2]. They can improve the confinement of fusion plasmas by the formation of transport barriers in the edge of tokamaks. Here, the relative density fluctuation levels are typically of order 0.1 – 1. Moreover, small density gradient (or e-folding) lengths can arise in particular in improved confinement modes. However, mean flow theory has so far been approached only by means of δf models, which couple fluctuating quantities to linear polarisation [3, 4].

In this contribution we extend the theoretical framework of poloidal $\mathbf{E} \times \mathbf{B}$ mean flows by accounting for high fluctuation amplitudes and nonlinear polarisation. To this end, we decompose the density and electric potential of a full-F gyro-fluid model [5]. From this we identify novel relevant agents in the mean flow dynamics. We discuss the meaning and significance of each term in detail. In the limit of small fluctuation amplitudes and high density gradient (or e-folding) lengths we recover the conventional Reynolds stress piece.

References