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Published in:
Book of abstracts

Publication date:
2001

Document Version
Publisher's PDF, also known as Version of record

Reynolds stress and effects of external and self-generated shear flows

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A major challenges in fusion research is the understanding and control of the plasma turbulence leading to anomalous transport of particles and energy. Experimentally obtained improved scenarios such as H-mode confinement regimes show a drastically reduced radial transport. The generation of H-mode confinement regimes seem to be closely related to poloidal shear flows in the edge region of the plasma. Generally, it is observed experimentally and numerically that shear flows in plasmas suppresses turbulence and transport. The generation mechanism of these flows is thus of great interest.

As presented analytically in [1] the so-called Reynolds stress gives a measure of the self-consistent flow generation in turbulent fluids and plasmas by the small-scale turbulent fluctuations. A measurement of the Reynolds stress can thus help to predict flows, e.g. shear flows in plasmas as demonstrated in [2]. However, the determination of the Reynolds stress requires measurements of the plasma potential, a task that is difficult in general and nearly impossible in hot plasmas in large devices.

In this work, we investigate the generation and the effect of shear flows in drift wave turbulence and the relation to the Reynolds stress. In particular, we look at an alternative way of estimating the Reynolds stress via the density fluctuations [3]. The advantage of this quantity, which we term the pseudo-Reynolds stress, is that accurate measurements of density fluctuations are much easier to obtain. We demonstrate the validity range of this quantity analytically and numerically using the Hasegawa-Wakatani model [4] in a 3D bounded geometry.

In order to clarify the role of the self-generated shear flow on the evolution of the drift wave fluctuations, we further investigate the influence of an imposed external shear flow on the development of the drift wave fluctuations and the turbulent transport.

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