mechanism of formation of turbulent structures under conditions of itg instability

Karbushev D.N., Khvesyuk V.I., Chirkov A.Yu.

Bauman Moscow State Technical University, Moscow, Russia, karbushevdn@bmstu.ru

In this paper, we study the mechanism of the onset of turbulent structures in plasma as a result of an action of unstable ITG (ionic temperature-gradient) drift waves, both in the absence and in the presence of a velocity shear.

In existing works, much attention is paid to the processes of turbulent transport in conditions of developed turbulence, while the processes of an onset of fluctuations are not considered. It is considered that ITG instability, considered in a linear approximation only, causes ITG turbulence, which in turn is suppressed by velocity shear. In this case, there is no relationship between an unstable ITG drift wave and the observed turbulent fluctuations.

A following picture of the origin of ITG turbulence is proposed. A separate monochromatic wave is considered, and an existence of a large set of waves in plasma is not excluded. Amplitude of the emerging unstable wave increases to a certain limit. And then a situation arises when the wave decays. The decay is accompanied by the formation of characteristic turbulent structures. Turbulent fluctuations of density and temperature observed in experiments are determined by the value of final wave amplitude. Then there is a gradual dissipation of the fluctuations and a resumption of the described cycle (a description corresponds to the observations in the experiment [1]). There is no knowledge of a reason for the wave decay in this picture, because of which it is impossible to establish a magnitude of the final amplitude and a magnitude of the fluctuations consequently.

To establish the cause, we conducted a qualitative analysis of changes in the local parameters of plasma within the wave over time. The analysis showed a strong increase in the density gradient along the wave, that is, in the direction perpendicular to an external density gradient. The external gradient is a cause of an appearance of the ITG wave. In our opinion, this circumstance is the cause of wave decay.

Based on the decay condition, an approximation formula is obtained. Corresponding estimates are compared with the known experimental data, both in the absence and in the presence of a velocity shear, which confirms the validity of the proposed mechanism for a formation of turbulent structures.

It has been shown that a velocity shear prevents the formation of large turbulent structures in plasma during their formation [2]. Under the influence of the velocity shear, a wave profile deforms (a stronger increase in the internal density gradient), and for this reason the wave decays at lower wave amplitudes, which means lower values of turbulent fluctuations are observed. The proposed interpretation is consistent with the experimental data obtained using BES diagnostics [3].

References

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