Excitation of turbulent fluctuations by unstable drift wave in a nonuniform plasma flow

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We consider mechanism of formation of turbulent perturbations in non-uniform plasma due to the drift instability in the magnetic field. The finite amplitude drift waves are studied. Since experimental data on the drift turbulence show good correspondence of the linear theory of drift instabilities, the instability growth rate is considered in the framework of the linear theory. The condition of decay of the initial perturbation is formulated. It is also the condition for the transition to the nonlinear stage. In the nonlinear regime, the conditions of existence of the wave are violated. There are two reasons for this. The first is the restriction of the amplitude growth. The second is the distortion of the initial wave profile under the action of sheared flow. In both cases, a region of large density gradient appears on the wave profile. The decay condition is quantitatively formulated as an equality of the maximum gradient of the density perturbation and unperturbed density gradient. Burgers-type differential equation is formulated for the evolution of the profile of density perturbation. Profile deformation under the action of shear flow is studied taking into account the spatial dependence of the flow velocity. To describe the decay of perturbation for the case of vanishing shear, the model diffusion operator is included to the profile evolution equation. Analysis of the physical meaning of the effective diffusion coefficient showed its conformity assessment based on the mixing length estimation proposed by Dupree. In this case, spatial scale is the inverse wave number. The time scale is the inversed instability growth rate. As the intensity of the shear flow increases the effective diffusion coefficient decreases. Numerical calculations showed that this decrease is well described by Itoh’s factor. The resulting dependence is qualitatively consistent with the peculiarities of the turbulent transport in magnetized plasma (L and H modes). Quantitative estimates [1–4] are also in reasonable agreement with the experimental data.

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