NONLINEAR ANALYSIS OF THE PLASMA WAVE DECAY

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Distortions of drift waves form connected with nonlinear processes agreed upon by influence of plasma shear flows on wave are considered. Plasma velocities are directed along line of wave propagation. It is shown that result of such an influence is strong transformation of wave. The overturn is achieved. It leads to wave decay.
PACS: 52.35.Qz; 52.55.Lf; 52.25.Fi

1. INTRODUCTION

Voluminous literature devotes problem of suppression of plasma instabilities by shear flows [1-6] etc. In order to solve this problem different approaches are proposed. In this work firstly approach based on analysis of distortion of drift wave shape is considered.

It is well-known variety of nonlinear wave processes and methods of them investigations. One of directions of analysis these phenomena is investigation of transformation of wave form and possible following them decay [7, 8, 9] also [10] and the references quoted therein. Within the framework of such analysis finite waves amplitudes and transformations of forms of waves are taken into account. In much in the same way sonic waves, sea waves and ion – sonic waves were investigated [7-10]. Taking into account of finite value of wave amplitude leads to distortion of originally harmonic wave and increasing steepness of wave shape. This statement is correctly both for waves in gases and waves in plasmas [9].

In this work similar task is considered in connection with drift waves in plasma under influence velocity shear plasma along wave velocity. It is necessary to keep in view important features of drift waves. Firstly motion of plasma particles in drift waves is transverse with respect to velocity propagation of wave. Secondly drift waves are unstable consequently it is necessary to take into account exponential increase of wave amplitude. The last feature did not consider till now. It is shown that distortion of originally harmonic form leads to overturn and decay of waves. Similar decay of drift waves was observed in experimental work [11].

This task is solved using two differ variety of approximations.

2. METHOD OF INDEPENDENT PARTICLES

This method is very simple and convenient in order to solve such a task. But it provides correct solution for weak deviations from sinusoidal wave shape in original linear state. Therefore it is possible to obtain only qualitative solution in such an approach.

It is considered propagation of drift wave mode inside slab parallel yOz plate. Axis Ox is directed along gradient of plasma density and plasma temperature. Magnetic field is directed along Oz axis. Transverse with respect to magnetic field component of drift wave is propagated along axis Oy.

First of all some results of analysis of particles motion in drift wave is presented using a simple method based on solution of 2D set equations. Coordinate system is connected with moving wave. Then for wave of constant amplitude a trajectory of every charged particle is ellipse (Fig. 1)

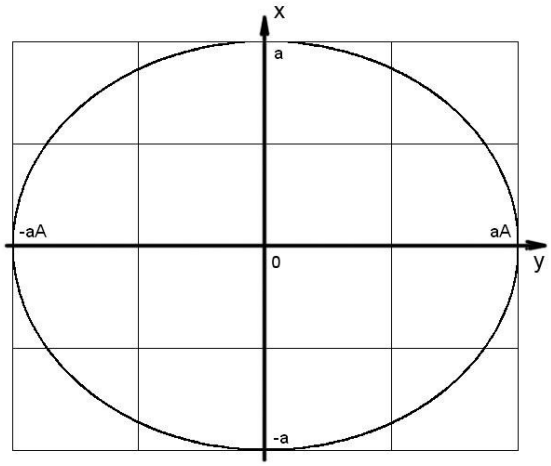


Fig. 1. The trajectory of charged particle inside drift wave having constant amplitude a

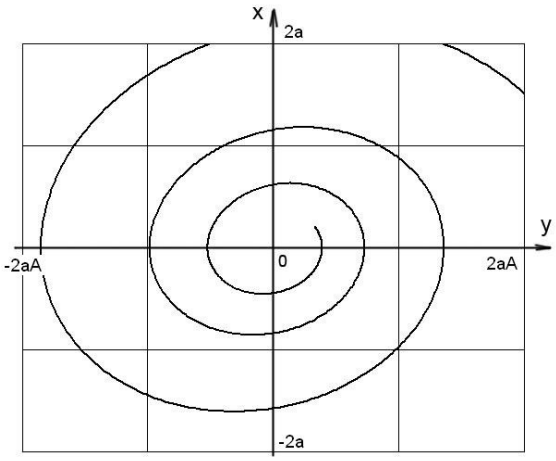


Fig. 2. The trajectory of charged particle inside drift wave having exponential increasing amplitude

$$\frac{x^2}{a^2} + \frac{y^2}{(aA)^2} = 1 .$$

Here A is constant in formula $v_y = Ax$. For wave with exponential increasing amplitude trajectory of particle is spiral (Fig. 2). In parametric form equations of spiral are

$$x(t) = a\exp(\gamma t)Sin(\omega t),$$

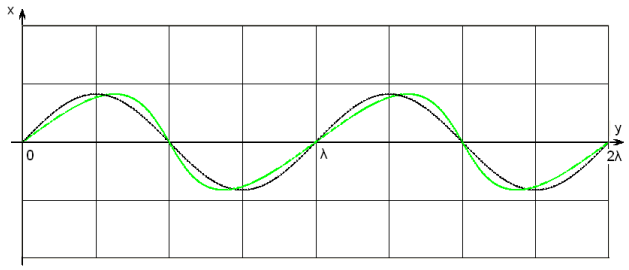
$$y(t) = \frac{Aa}{\omega^2 + \gamma^2}\{\exp(\gamma t)[\gamma Cos(\omega t) - \omega Sin(\omega t)] - \gamma\}$$

Lower hydrodynamic approach is considered.

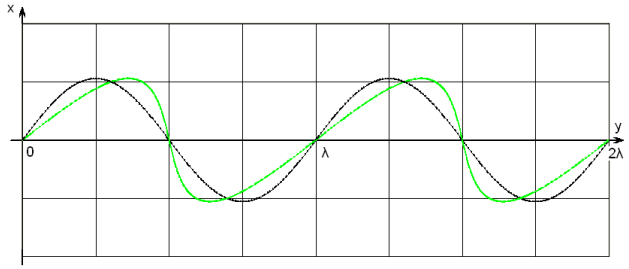
3. HYDRODYNAMIC METHOD

Hydrodynamic approach is based on the following starting points. Velocity distribution along direction of wave propagation (Oy axis) is given. Plasma density is taken as compressible. In cross direction with respect to the wave propagation (Ox axis) the particles motion is taken into account as electrical drift. One is determined by electric field arising because of density gradients along Oy axis.

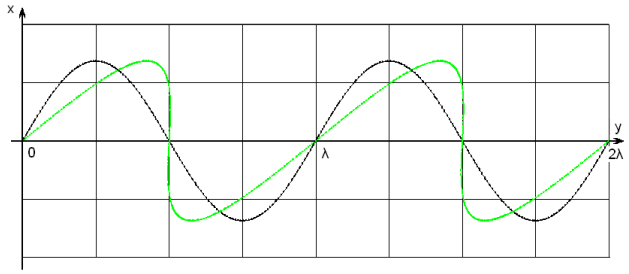
The main advantage this model is possibility of to consider essentially nonlinear stages wave existence. Then the overturn is achieved. Corresponding numerical results are presented in Fig. 3, 4. On these Figs. comparison harmonic and perturbed waves is presented.



$t = t_1$

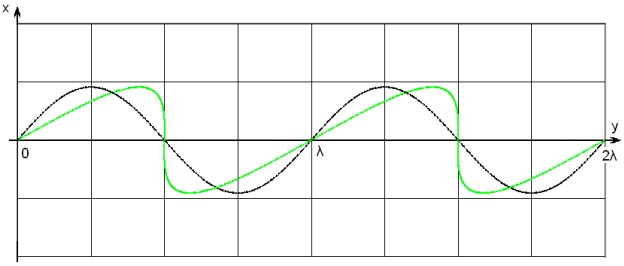


$t = t_2$



$t = t_3$

Fig. 3. Dynamics of drift wave mode under influence of velocity shear, $v_y = Ax$. Moment t_3 corresponds to condition equality infinity of derivative perturbed wave



$t_3(2A) < t_3(A)$

Fig. 4. Dynamics of drift wave mode under influence of velocity shear, $v_y = 2Ax$. In moment of achievement of overturn amplitude value of wave less than in the case when $v_y = Ax$

4. CONCLUSIONS

It is shown that influence of shear flow on drift wave leads to wave overturn. It means following decay of wave. Added analysis shows that wave decay can take place before achievement overturn namely when gradient density in wave $\partial n / \partial y$ and gradient density in plasma $\partial n_0 / \partial x$ will become equal. From estimations follows that this equality appears earlier than overturn.

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Article received 22.09.08

НЕЛИНЕЙНЫЙ АНАЛИЗ РАСПАДА ПЛАЗМЕННОЙ ВОЛНЫ

В.И. Хвесюк, Д.Н. Карбушев

Рассматриваются искажения формы дрейфовых волн, связанные с нелинейными процессами, вызываемыми воздействием неоднородных скоростей плазмы, направленных вдоль линии распространения волны. Показано, что в результате такого воздействия волна существенно искажается, вплоть до опрокидывания. Это ведёт к распаду волны.

НЕЛІНІЙНИЙ АНАЛІЗ РОЗПАДУ ПЛАЗМОВОЇ ХВИЛІ

В.І. Хвесюк, Д.М. Карбушев

Розглянуто перекривлення форми дрейфових хвиль, пов'язане з нелінійними процесами, які визвано впливом неоднорідних швидкостей плазми, направленими вздовж лінії розповсюдження хвилі. Показано, що внаслідок такого впливу хвиля істотно перекривлюється аж до перекидання. Це призводить до розпаду хвилі.