THEORETICAL MODEL FOR THE EXPERIMENTALLY OBSERVED GAM'S SATELLITES

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The high-frequency branch of zonal flows, the so-called geodesic acoustic modes (GAMs) [1], are observed in a variety of experiments with toroidal plasma, are actively studied theoretically and in numerical modeling, however so far there is no clear picture of their dynamics. One of the problems requiring theoretical interpretation is the observed "double–humping" of the GAM spectrum – the presence of two amplitude peaks near the theoretically calculated GAM frequency. The splitting of the GAM frequency is observed, in particular, on tokamaks ASDEX Upgrade [2] and DIII-D [3]; the team of the T-10 tokamak uses the term "satellites" for this phenomenon [4].

In this paper, the theoretical model is proposed, which explains the presence of GAM's satellites in the spectrum of plasma electric potential oscillations by the nonlinear impact of the low-frequency zonal flow (ZF) [5] on GAM. In the linear approximation, the low-frequency ZF, like GAM, is one of the eigenmodes of toroidal plasma. The finite frequency of ZF is associated with the stationary plasma rotation [6] and vanishes in its absence. The interaction of eigenmodes with significantly different frequencies leads to the modulation of GAM's amplitude on the frequency of ZF. In the spectrum of oscillations this effect manifests itself in the form of two side-band harmonics near the GAM frequency. Thus, the frequency shift between the GAM peaks is equal to twice the ZF frequency that correlates with the experiment.

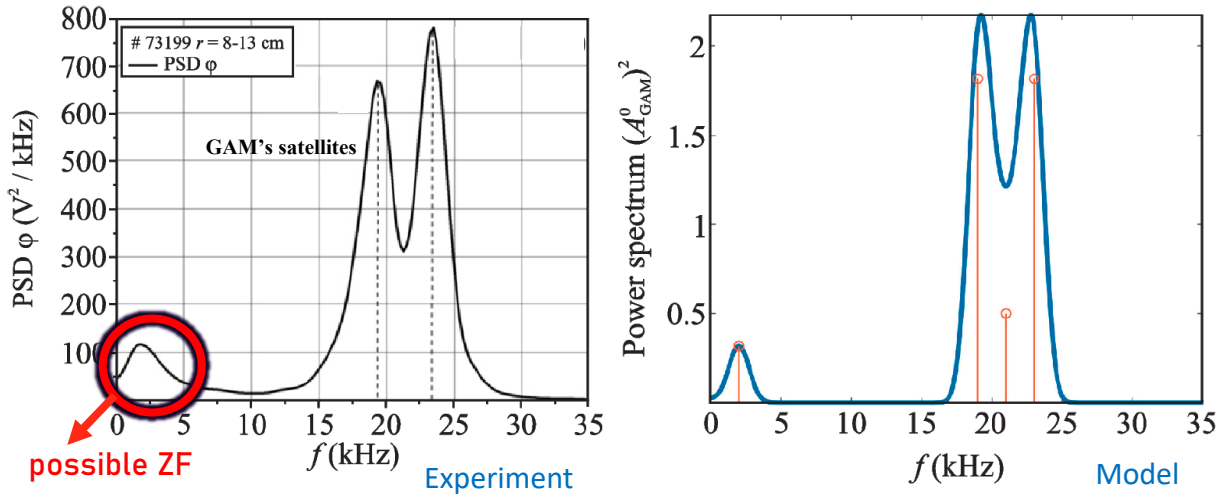

Fig.1. Power spectrum of electric oscillations in the Ohmic stage of the T-10 tokamak discharge [7] (left), power spectrum calculated within the framework of the nonlinear GAM-ZF model [5] (right).

Figure 1 (on the left) shows the experimentally measured spectrum of electric potential oscillations in the Ohmic stage of the T-10 tokamak plasma discharge [7]. There are two peaks near the frequency of GAM: $f \sim 19$ kHz and $f \sim 23$ kHz. The additional peak in the region of 2 kHz is clearly observed, which, according to the proposed hypothesis, corresponds to ZF. The frequency difference of the satellites is equal to twice the frequency of ZF.

Figure 1 (on the right) shows the calculated power spectrum of oscillating electric field in the frame of the proposed theoretical model. The observed pattern is well repeated.

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