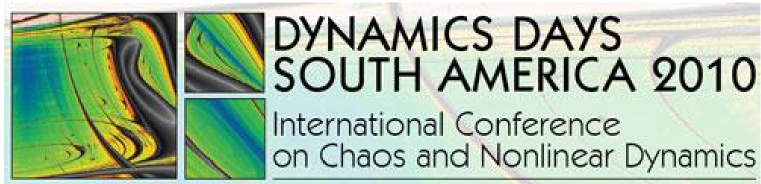

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ZONAL FLOW INFLUENCE IN THE GENERATION OF INSTABILITY IN FOUR WAVE INTERACTION

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In tokamaks radial particle transport is induced by electrostatic drift turbulence at the plasma edge. This turbulence is much affected by the plasma zonal flow. The relation between drift waves and zonal flow has been investigated to better understand the transport and the turbulence. To reduce the transport and improve the plasma confinement, turbulence control can be achieved by conveniently varying the radial electric field that gives rise to the zonal flow.

Previous works involving the three wave interaction model, described by the Hasegawa-Mima equation, were considered for parameters chosen from plasma confined in Brazilian TBR tokamak [1]. Some aspects of the temporal dynamics exhibited by the three-wave interaction model was investigated, with special emphasis on a chaotic regime found for a wide range of the wave decay rate. An intermittent transition from periodic to chaotic behavior was observed and some statistical properties, such as the burst and laminar length interval durations, were obtained. The conservative case of four wave interaction was investigated for a Hamiltonian model [2].

In this context, we analyze the coupling between drift waves and zonal flow. This can be properly handled by a four-wave (three waves plus a zonal flow) interaction model with quadratic nonlinearities and linear growth/decay rates used to investigate the occurrence of drift-wave turbulence in the tokamak edge plasma. For that we consider numerical solutions of the generalized Charney-Hasegawa-Mima equation in the presence of a zonal flow linear growth/decay rates.

The four coupled wave solutions of Charney-Hasegawa-Mima equation satisfy the equations [3]

$$\frac{dA_0}{dt} = -\,\Omega_0\frac{[1+(k_+^2-q^2)]}{(1+k_0^2\hat{\rho}^2)}a_+B^* + \Omega_0\frac{[1+(k_-^2-q^2)]}{(1+k_0^2\hat{\rho}^2)}a_-B + \nu_1A_0$$

$$\frac{da_+}{dt} + i\delta_+a_+ = \Omega_0\frac{[1+(k_0^2-q^2)]}{(1+k_+^2\hat{\rho}^2)}A_0B + \nu_2a_+$$

$$\frac{da_-}{dt} + i\delta_-a_- = -\Omega_0\frac{[1+(k_0^2-q^2)]}{(1+k_-^2\hat{\rho}^2)}A_0B^* + \nu_3a_-$$

$$\frac{dB}{dt} = \Omega_0\frac{(k_+^2-k_0^2)}{q^2}a_+A_0^* - \Omega_0\frac{(k_-^2-k_0^2)}{q^2}a_-^*A_0 + \nu_4B$$

where A_0 is the pump wave, $a_\pm$ are the sideband drift waves, and B is the zonal flow, and $\mathbf{k}_0 = (k_x, k_y, 0)$ is the wave vector of the pump wave, $\mathbf{q} = (q, 0, 0)$ is the vector wave of the zonal flow, $\mathbf{k}_\pm = (k_x \pm q, k_y, 0)$ are the vector waves of the two sidebands. The quantity $\Omega_0 = qk_y$, $\delta_\pm$ represents a small mismatch of frequency between the pump and the sidebands waves. The parameters ν_i, for $i = 1, 2, 3, 4$, are growth/decay coefficients.

To obtain numerical results we choose model parameters taken from a typical set of measurements of the floating electrostatic potential at the tokamak edge.

Now, we analyze the four coupled wave solutions with the zonal flow described by one wave. The found solutions depend on some plasma equilibrium, as the density gradient and the radial electric field modulation, and wave parameters. Thus, one relevant solution describes a dominant drift wave generating two side bands and the zonal flow. In these cases, the waves propagation in the plasma explains the onset of the plasma edge turbulence. Moreover, for other parameters, the side band and zonal flow growth is low and these waves remain with low amplitudes. This reported instability that generates side bands should be related to the observed turbulent cascade scenario and generation of broad frequency spectrum and is very sensitive to the zonal flow modulation and density gradient.

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