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ON THE IONIZATION-TEMPERATURE INSTABILITY ROLE IN Z-PINCH HOT SPOTS GENERATING

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Abstract

This paper is devoted to the investigation of instability evolution, generated neither by initial Z-pinch outer boundary perturbation, but by perturbation in initial temperature [1].

Treatment of this process was developed numerically, using 2D MHD code MAG [2, 3]

Obtained results show, that nevertheless higher modes appear, they didn't become the leading modes.

Introduction

Nowadays the idea, that the process of hot spot generation is the consequence of the initial perturbation of Z-pinch boundary evolution, is generally accepted.

But in some experiments the phenomena of plasma stratification along Z-pinch axis was found. In the paper [1] the condition of this phenomena appearance has been analyzed and the hypothesis, that this phenomena is caused by axial perturbations, appeared because of Ionization-temperature instability, has been discussed.

The present paper is devoted to the numerical investigation of this hypothesis.

Brief description of numerical experiments

A number of calculations with varying initial values of variables has been performed. Because the hypothesis is connected with instability development in single wire the correspondent initial data has been used: generator current of 200 kA was taken and assumed to be constant. Initial radius of wire was taken to 10μm (close to usial experimental data). By 1D MHD code ERA [4] the calculations of initial time of electroexplosion have been conducted. It has been obtained that the radius of expanded wire is about 0.3 cm.

By 2D MHD code MAG several cases of wire compression have been analyzed:

1. It has been supposed that wire before compression is homogeneous
2. Cold core existing is taken into account. Therefore the density profile was set to $\rho(r) = \rho_o \cdot r_o/r$ and temperature $T(r) = T_o \cdot r/r_o$
3. Initial density and temperature distribution at the time of maximum expansion was taken from ERA code

The perturbation in temperature was taken in the following cases:

- in the form of sine wave per z-direction and damped exponential as far as penetration into the plasma.

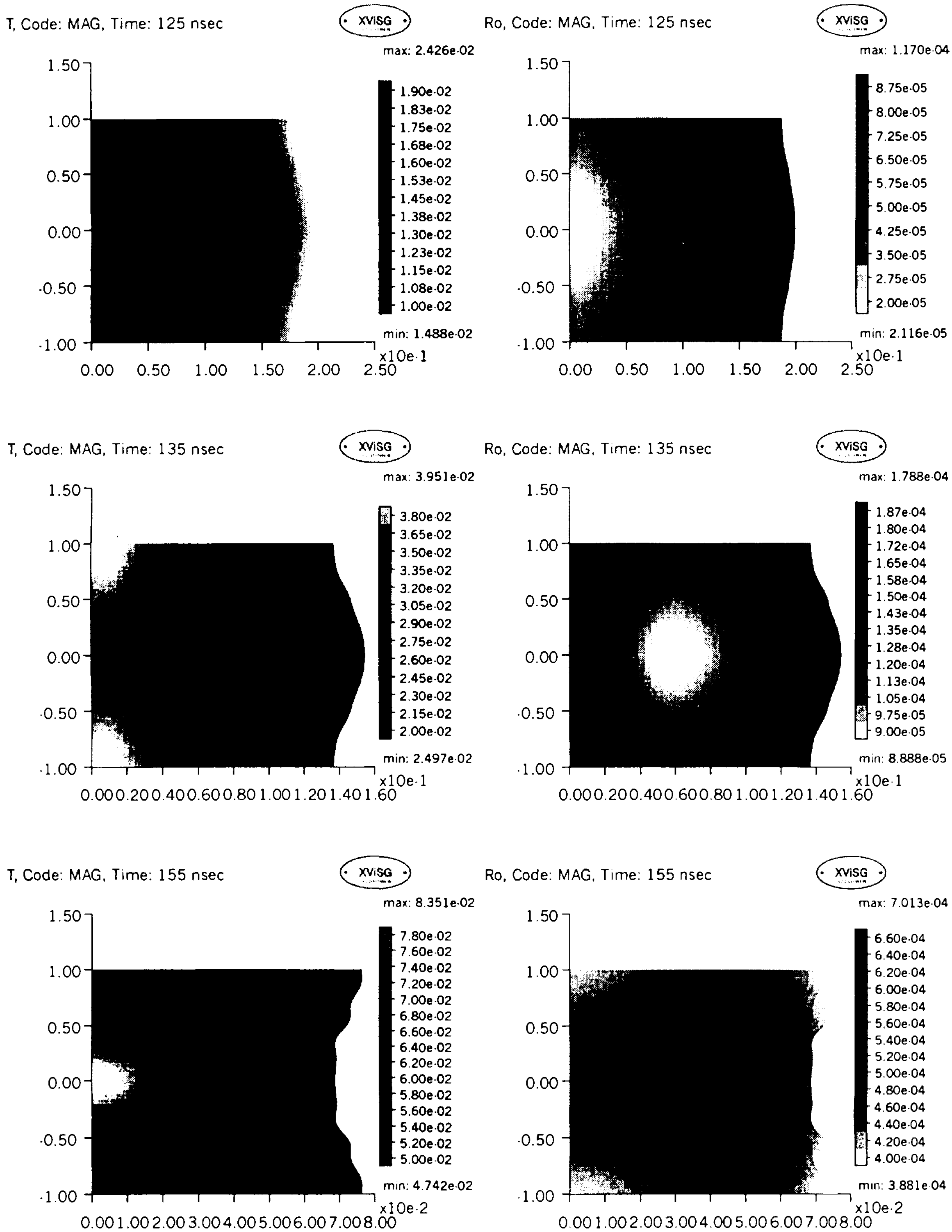

Fig. 1

Ionization - Temperature Instability Development.
Left - Temperature (keV), Right - Density (g/cm^3).
Corresponding times: 125, 135 and 155 nsec.

- composition of different modes. One mode was taken to be leading (k=1) and next modes (k=2,3,4,...) were added to the leading mode.

For all cases the dynamics of processes is coincided in common (see Fig.1). The instability is developing due to different pressure of plasma, cavity reaches the axis (Fig.1, upper pictures), reflected from axis, produces two shock waves propagating in opposite directions. These shock waves are met at other place and new hot spot is appeared (Fig.1, lower pictures). The processes is repeated again. During current period the plasma is oscillated several times.

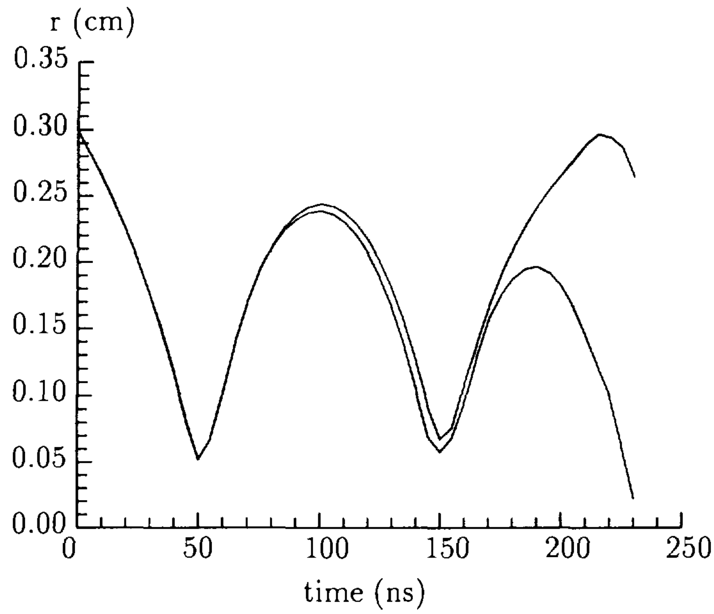

Figure 2: Minimum and maximum radii of Z-pinch outer boundary vs time

In Fig.2 one can see the graph of minimum and maximum radii of Z-pinch outer boundary versus time. It characterizes the process of instability growing. At the initial time difference between them is very little, after Z-pinch was compressed for the first time it almost hasn't grown. The main growing of instability occurs during the third compressing.

The time dependence of modes amplitude vs. time is shown in Fig.3. The first mode is the main one, the other modes are growing in time, but the second mode is growing much faster then the other modes. It can be interpreted as the modes saturation processes.

Conclusion

Some calculations have been conducted for the hypothesis analysis of ionization-temperature instability development in Z-pinch. One can concluded that obtained plasma column oscillation and axial motion could explain the hot spot motion alone the axis for these parameters of wire compression. The calculated mechanism of modes saturation could help in analysis of observed experimental data when some hot spots are degenerated and new ones are arisen but in smaller quantity.

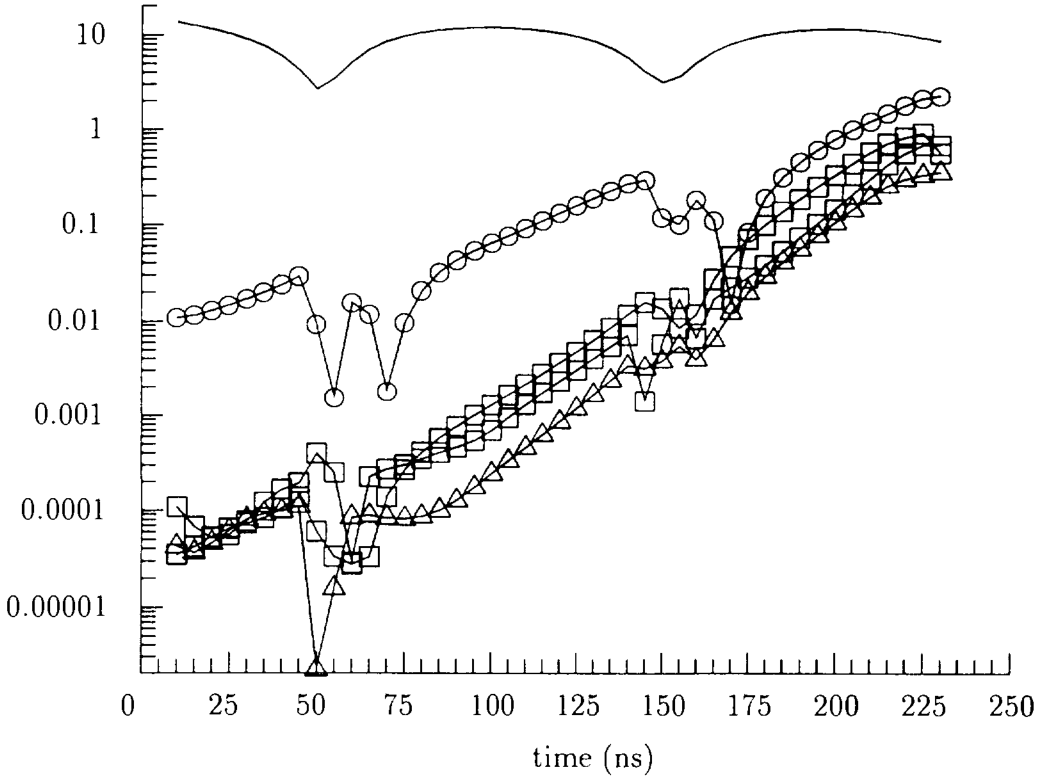

Figure 3: Modes amplitude vs. time. Without sign – main mode, circles – second mode, squares – third one, triangles – fourth one

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