RESUME OF THE PhD THESIS

"CONTRIBUTION TO THE STUDY OF INSTABILITY IN DISCHARGE PLASMA USING NONLINEAR DYNAMICS"

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This thesis is divided into four chapters, conclusions and bibliography. The original results were published in a number of 11 works: 5 articles in ISI rated journals (3 international and 2 national), 3 articles in CNCSIS B + journals, two books of which one at national publishing house and another abroad and a paper presented at an international conference.

The main original results of the thesis are:

In Chapter I, entitled "Analysis of double cathode effect using elements of nonlinear dynamics", a theory of double cathode effect using elements of nonlinear dynamics have been developed. This was possible by using elliptic functions formalism, formalism that allows the integration of dynamic equations in analytical form, but not numerical. For the double cathode effect to be initiated, it is necessary like those two negative light of the planar electrode to overlap. From a mathematical perspective, it is equivalent with two elliptic functions resulted from the inversion of some complete elliptic integrals of first order. We remind that two elliptic functions are equivalent if and only if between the ratio of their periods exists a homograph transformation. Moreover, the equivalence of elliptic functions involves an algebric relationship between them. Considering now that the pressure of the working gas meets the ideal gas equation, finally standard result is obtained, namely the product of the discharge length and gas pressure in the chamber is constant. This constant is a function of both the nature of the gas and the potential of the cathode.

Chapter 2 is entitled "Specific transport laws at mesoscopic scale via non differentiability. Electrical conductivity in nano-structures". A mathematical model was built, explaining the mechanisms of transport in nanostructures considering that the microparticles of a "electronic plasmas" moves on continuous, but non-differentiable curve, i.e. on fractals. Based on Newton's equation in covariant form, the Schrӧdinger type equation was obtained and also, the corresponding hydrodynamic model, considering that fluid movement is irotational, with fractal dimension $D_F = 1$ and $D_F = 2$. Both interaction scales (macroscopic and microscopic) and fractal dimension and fractal potential, imposed the transport mechanisms. Compatibility between the macroscopic and the microscopic scale led to a quantization condition for electric conductance in nanostructures.

Chapter 3 is named "Multi- peak structure of the ionic current in the plasma produced by the laser. Experimental and theoretical considerations". Experimental transient ionic current recorded by a collector probe during the expansion of plasma has been reported for Sn and Li targets, in different focusing conditions and laser energies. The resulting multi-peak structure revealed a process of dividing the plasma even at low "ambient" pressure. In our opinion, this takes place because the secondary structure, in the form of 'mushroom', extends in the atmosphere of evaporated material, in the early stages of the laser-target interaction. Using a simple hydrodynamic model, numerical simulations reproduced well this behavior. A fractal hydrodynamic model developed in a non-differentiable space, having as solutions the Gauss wave packet and Gauss superposition type packages, explained plasma expansion in vacuum and gave a reasonable mathematical description of the dividing process of the plasma.

In Chapter 4, "Experimental and Theoretical Investigation of multiple double layers in plasma and their evolution towards chaos", an experimental scenario of transition to chaos through a cascade of subharmonic bifurcations was highlighted, in connection with the generation and dynamics of multiple double layers in a discharge plasma. Nonlinear dynamic analysis were carried out at different increasing values of the voltage applied to the electrode. Moreover, axial profiles of the electric field were plotted and, respectively, of the electrical charge density on the electrode . Considering that the movements of plasma discharge particle take place on fractal curves, a mathematical model based on TRS has been developed, in order to describe the dynamics of plasma discharge. Thus, by using fractal hydrodynamics, self-organization of a plasma discharge in multiple double layers was analyzed. In such circumstances, a good correlation between the experimental and theoretical dependences was obtained. Using cloning formalism, a fractal Reynolds type criteria for the evolution to chaos through a cascade of subharmonic bifurcations space-time was established. As a final conclusion , we can observe a good agreement between experimental and theoretical results .

Results states that plasma is a complex system due to interactions between components, in our case the interaction between electrons, ions and neutral, exhibiting properties of adaptability, self-organization and emergence. The use of nonlinear dynamics to analyze such a system highlights the properties mentioned above.

In this context, the instabilities are generated at the order - disorder limit under the form of transition between any two scales of resolution, for example, in the transition between non-cvasiautonom and cvasiautonom regimes, as well as in the case of the complex fluids flow in the form of Shapiro type steps, like in the case of nanostructures, generation of the multi -peak structure or shock waves and vortex as result of the expansion of ablation plasma or at the transition double-layer – multiple layer. Mathematically, these instabilities appear as asymptotic limits in either analytical solutions or the numerical solutions.