Ph. D. Thesis (KONDJI Yvon Simplice)

Title: DYNAMIQUE ET SYNCHRONISATION DES CIRCUITS ÉLECTRIQUES CONTENANT UNE LAME DE DIHYDROGÉNOPHOSPHATE DE POTASSIUM

Abstract

The primary aim of this work is to study the dynamical behaviors of a strip of KH_2PO_4 or KDP close to the temperature of transition. A strip of KDP crystal is inserted in a simple RL series circuit supplied by a sinusoidal driving voltage. Firstly, we study the influence of the voltage excitation parameters on the circuit dynamical states in the paraelectric and ferroelectric phases. Secondly, we deal with the synchronization of a network of RL-KDP strip circuits and coupled by capacitors. Finally, we analyze the microscopic behavior of the protons and heavy ions in the KDP strip.

This work starts with the known information on piezoelectricity and some applications. It is followed with the presentation of the crystalline structure KH_2PO_4 as well as the equations of motion of the protons and heavy ions of this crystal under periodic excitation. We then present the mathematical and numerical tools used throughout the work.

Varying the parameters of the excitation, we observe (both in paraelectric and ferroelectric phases) the hysteresis phenomenon, regular behaviors and dissipative chaos. Melnikov's theory is used to analytically determine the border between the regular oscillations and the domain of Hamiltonian chaos. The fractal geometry of the attraction basins of the homoclinic and heteroclinic orbits are presented.

Varying the electric coefficient of the coupling, we find the domain of complete synchronization in the network. The critical value of the coupling above which complete synchronization is observed increases with the number N

of the devices in the network. This critical value is larger in the ferroelectric phase than in the paraelectric phase.

For low values of the amplitude of excitation, we note that the protons and heavy ions of the KDP crystal oscillate in a sinusoidal way around their equilibrium position. This oscillation becomes disordered or chaotic above a critical value of the amplitude of the excitation.