UNIVERSITY OF CRETE
DEPARTMENT OF PHYSICS

CRETE CENTER FOR
QUANTUM COMPLEXITY
AND NANOTECHNOLOGY

ΓΕΝΙΚΟ ΣΕΜΙΝΑΡΙΟ ΤΜΗΜΑΤΟΣ ΦΥΣΙΚΗΣ

PHYSICS COLLOQUIUM

Thursday, 14 May 2015
17:00 -18:00
3rd Floor Seminar Room

"Thermodynamics and mechanics of nerves"

Prof. Thomas Heimburg

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Abstract

It is a central paradigm in biology that excitatory events in cells are of purely electrical nature. It is believed that they are controlled by a class of proteins called ion channels. For instance, the nervous impulse is attributed to the activity of potassium and sodium channels. Upon a change in voltage these channel proteins open a pore and ions flow across the membranes along their gradients. As a consequence, they change the electrical properties of the nerve and cause the emergence of electrical pulses. Such nerve pulses dissipate a lot of free energy. Therefore, the famous electrophysiologist Alan L. Hodgkin compared the active nerve to a "burning fuse of gunpowder". However, it is widely unknown that during the nerve impulse also the temperature, the thickness and the length of nerves change. No dissipation of energy is observed in experiments. In contrast to common beliefs, many properties of nerve pulses rather resemble those of local compressional mechanical pulses called solitons. Solitons are pulses that travel without changes in shape and without dissipation of energy. Thus, the electrical pulses in classical electrophysiology and electromechanical solitons differ largely in their physical implications. The description of solitary pulses requires the language of thermodynamics and hydrodynamics rather than that of electrical circuits. In this presentation we show how the properties of nerves can be understood on the basis of a purely physical description. Ion-channel-like events show up as thermal fluctuations in the membrane. The physical picture includes an explanation for the phenomenon of anesthesia caused by small membrane-soluble drugs. Thus, many known physiological phenomena re-emerge in a completely different conceptual framework.