



THE CHINESE UNIVERSITY OF HONG KONG
Department of Physics
COLLOQUIUM

Nonlinear Physics in Cardiac Systems: Control of Oscillatory Behavior

by

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Time: 4:00 - 5:00 p.m.

Place: L2 Science Centre, CUHK

(Light refreshments will be served 20 minutes prior to the colloquium.)

ALL INTERESTED ARE WELCOME

Abstract

I will briefly introduce the nonlinear physics involve in cardiac systems and discuss our recent theoretical and experimental work. The first is the frequency variation with time in cultured cardiac cells, whose oscillatory dynamics can be modeled by coupled excitable elements in the presence of noise. For two such coupled elements, it is found that their frequencies are enhanced by the coupling and will synchronize at a frequency higher than the uncoupled frequencies of each element. As the coupling increases, there is an unexpected peak in the frequency enhancement before reaching synchronization. Similar behaviors are also obtained for a square lattice network of these coupled noisy excitable elements. The simulation results can be understood with a simplified analytic model based on the excitation across a potential barrier whose height is controlled by the coupling. Most importantly, these simulations can quantitatively reproduce the unexpected peak in the variation of the beating rates observed in our experiments. The second is about the dramatic reduction of cardiac alternans by small perturbations in pacing scheme. Predictions and validity of this control method have been verified by both experiments performed with isolated heart preparations and numerical simulations. A nonlinear return map for this novel pacing scheme based on action potential duration restitution response is proposed to explain the working mechanism of the control.