APPLIED MATHEMATICS COLLOQUIUM

VORTEX DYNAMICS IN REACTION-DIFFUSION EQUATIONS WITH APPLICATIONS TO ELECTROPHYSIOLOGY

ALEXANDER PANFILOV
Department of Theoretical Biology
Utrecht University
The Netherlands

ABSTRACT:

Cardiac arrhythmias and sudden cardiac death is the leading cause of death accounting for about 1 death in 10 in industrialized countries. Although cardiac arrhythmias has been studied for well over a century, their underlying mechanisms remain largely unknown. One of the main problems in studies of cardiac arrhythmias is that they occur at the level of the whole organ only, while in most of the cases only single cell experiments can be performed. Due to these limitations alternative approaches such as mathematical modeling are of great interest. From mathematical point of view excitation of the heart is described by a system of non-linear parabolic PDEs of the reaction diffusion type with anisotropic diffusion operator. Cardiac arrhythmias correspond to the solutions of these equations in form of 2D or 3D vortices characterized by their filaments. In my talk, I will present a short overview of two main directions of our research:

[1]. Development of virtual human heart model. Here I will report on the development of an anatomically accurate model for the human heart. The model integrates our knowledge about electrophysiology of the human heart from a single cell to the whole organ and allows us to study mechanisms of cardiac arrhythmias in the human heart, where experimental interventions are very limited. I will present recent results of our studies of 3D organization of ventricular fibrillation in human heart and compare our conclusions to the available experimental and clinical data. In general, we find that ventricular fibrillation in the human heart may be organized by a small number of vortex filaments (around 6) and should have much simpler structure than thought before.

[2]. Pattern formation in the reaction-diffusion-mechanics system. Recently we have started study of a new class of PDEs: coupled reaction-diffusion-mechanics systems, which combines the parabolic reaction-diffusion equations with the elliptic equations of finite elasticity. I will briefly report on our approach and present results on the onset of the pacemakers induced by deformation, onset of spatio-temporal chaos and onset of dynamical attractors for spiral waves due to the mechanics-reaction-diffusion feedback. In terms of applications this study focuses on effects of cardiac contraction on the onset of cardiac arrhythmias.

MONDAY, MAY 15, 2006
4:30 PM
Building 2, Room 105

Reception at 4:00 PM in Building 4, Room 174.
(Math Majors Lounge)

Applied Math Colloquium: http://www-math.mit.edu/amc/spring06
Math Department: http://www-math.mit.edu

Massachusetts Institute of Technology
Department of Mathematics
Cambridge, MA 02139