2011 Special Program: Two-Phase Flow, Interface Flow and Related Phenomena

Heart modeling and its applications in investigating arrhythmogenesis

2011 - 12 - 14 (Wed.)
15:00 - 17:00
308, Mathematics Research Center Building (ori. New Math. Bldg.)

The heart is a very complex organ with multiscale structures, from microscopic single cell or even molecular ion channel, the mesoscopic tissue, to the macroscopic whole organ. The corresponding modeling techniques are varying with different scales. In this talk, I will mainly focus on the modeling issues of the cell and channel scales, especially the gating mechanism of ion channel.

Ion channel plays important role in physiological functionality. Ions transportation in this channel can be modeled by the well-known Poisson-Nernst-Planck (PNP) model and the recently developed Energetic Variational Approach (EVA). About the gating issue, three types of modeling approaches will be introduced and compared: Hodgkin-Huxley, Markov chain, and Smoluchowski (Fokker-Planck type model), more refined for the later. In particular, with the correct crystalline structure of ion channel, the kinetic Markov model can be constructed properly by the Smoluchowski approach.

With more understanding of the structures and working mechanisms of ion channels, the speedup of drug design and adoption of more suitable therapy policy are expected. As examples, I will show our recent works on some genetic heart diseases: Timothy syndrome, Catecholaminergic Polymorphic Ventricular Tachycardia (CPVT) to clarify the relationship.

Finally, some modeling/computational challenges and perspectives will be addressed, such as healthy human heart modeling, GPU computation, drug developments…