

Speaker: Willi Jäger
IWR, Heidelberg University

Title: Plaque formation in blood vessels: Numerical methods and simulation results.
Challenges for future research

Abstract:

Mathematical modelling and simulation of fluid-structure interaction problems are in the focus of research already for a longer period. However, taking into account also chemical reactions, leading to structural changes, including changes of mechanical properties of the solid phase is a rather new, but for many applications highly important area. This lecture is dealing in particular with flow and transport in blood vessels and their biomechanical and biochemical interactions with the vessel walls leading to plaque formation. A corresponding specific model system will be derived and discussed in the lecture presented by Maria Neuss-Radu. This problem as prototype for reactive flow and transport in a vessel system, where chemically active substances, penetrating into the solid wall and interactions inside the wall, lead to changes of volume and of the mechanical properties of the wall. The following topics will be covered in this talk:

- Numerical algorithms developed and used to simulate the dynamics of such a mechano-chemical fluid-structure interaction problem:
The arbitrary Lagrangian Eulerian method (ALE) is chosen to solve the systems numerically. Temporal discretization of the fully coupled monolithic model is accomplished by time-stepping schemes, spatial discretization by stabilized finite elements. The numerical approach is verified by numerical tests.
- Results of simulations of the plaque formation for realistic systems parameters:
The evolving structures are matching clinical observations. The time scale of the formation is in the simulation of comparable order as in reality.
- Necessary improvements in mathematical modelling and in simulation of plaque formation.
- Inflammation and the role of hypoxia.

References:

Y. Yang, Th. Richter, W. Jäger and M. Neuss-Radu: *An ALE approach to mechano-chemical processes in fluid-structure interactions*. Submitted to International Journal for Numerical Methods in Fluids, Oct. 2015
Y. Yang, W. Jäger, M. Neuss-Radu and Th. Richter: *Mathematical modelling and simulation of the evolution of plaques in blood vessels*. J. Math. Biol. Sept. 2015 [Epub ahead of print]
V. Malieva, F. Heimann, W. Jäger, P. Bastian:
Biot-Stokes free boundary interaction problem with a pressure jump at the interface: numerical verification of a mathematical model for an osmotic swelling of a poroelastic medium.
To be submitted to Computer Methods in Applied Mechanics and Engineering Nov. 2015
V. Malieva: *Mathematical modelling and simulations of brain cell swelling under ischaemic conditions*.
PhD thesis, Heidelberg University May 2015