Modelling, Analysis and Simulation of Thrombosis and Haemostasis

F. Weller[1] **and W. Jäger**[1]

Abstract: Heart attacks and strokes account for the majority of deaths in the western society. Since thrombotic complications preferentially arise at sites of disturbed flow, investigation of the coupling of haemostasis and fluid mechanics is essential to understand the underlying mechanisms. It is well established that elevated shear stresses activate platelets and promote their adhesion to injured tissue on the one hand, on the other hand counteract coagulation. The growing thrombus markedly disturbs the flow of blood and may even lead to a complete occlusion of the vessel. Despite these insights, the exact mechanisms of flow affecting hemodynamics are not yet understood in detail.

Previous research of my diploma thesis concentrated on the mathematical modelling of the interplay between platelets and the coagulation cascade, leading to a system of nonlinear reaction-convection-diffusion equations with mixed boundary conditions, which was solved analytically. By using state-of-the-art finite element methods, numerical simulations were performed which showed that the model is very well reflecting the localization of haemostatic processes to the site of injury. This first approach thus provided a suitable description of the intermediate stages of platelet deposition. However, it treated blood flow as being given, i.e. flow disturbance due to aggregate growth was neglected. My ongoing work focuses on extending the model to include shear induced platelet activation, saturation of the reactive surface and thrombus growth. Hence, a free boundary value problem is obtained, comprising ordinary differential equations on the initial reactive surface as well as fully coupled species and fluid dynamic equations. The boundary conditions become nonlinear if ligands are taken into account, which are important in mediating platelet adhesion and aggregation. The analytical and numerical solution of the arising challenges will provide a better understanding of both adhesion and growth processes - hopefully enlightening relevant clinical questions.

[1] Interdisciplinary Center for Scientific Computing
University of Heidelberg
Im Neuenheimer Feld 368, 69120 Heidelberg, Germany
frederic.weller@iwr.uni-heidelberg.de
jaeger@iwr.uni-heidelberg.de