Thesis proposal : Modeling and Numerical Simulations of Blood Flows (Applied Mathematics/Physics)

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Supervision:

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Send a CV and a motivation letter as well as at least one person to contact to support your application.

Financial support :

ANR project VIVABRAIN `http://icube-vivabrain.unistra.fr`

Location : LIPhy[1]/LJK[2] Grenoble

Description

This thesis is part of the ANR project VIVABRAIN `http://icube-vivabrain.unistra.fr` involving researchers from different disciplines (applied mathematics, physics, computer science and radiology).

The main objective is to study different hypotheses made on the rheology of the blood (Newtonian vs. non Newtonian vs. particles in flow). In this context, we will, in particular, propose a method that would allow access to the rigidity of RBCs from macroscopic data (like the apparent viscosity of blood). Its purpose is to allow the diagnosis of some pathologies related to the rigidity of RBCs. We will have access, for the computations, to 3D vascular meshes generated by MR images in the framework of the VIVABRAIN ANR project. It will require to *(i)* set up an integrated numerical model that will be suitable

[1] http://www-liphy.ujf-grenoble.fr
[2] http://www-ljk.imag.fr

to simulate blood flow in these complex geometries and eventually in a complete coupled network, *(ii)* and develop highly efficient algorithms for the simulation of the motion of a large number of particles immersed in a fluid, in order to provide new results on the behavior of these complex systems and to deliver high-performance software for the simulation of thousands of particles in 2D and 3D domains based on the Feel++ `http://www.feelpp.org` library. Such simulations will indeed be computationally extremely intensive. Note that a special attention will be given to close-range interactions (lubrication forces), which are likely to play a major role in the concentrated case. Lubrication forces, which depend singularly upon inter-object distances, will be integrated in the numerical models. The thesis work will combine different numerical methods from the numerical and theoritical point of view. More precisely, we will use the following ingredients *(i)* High order discretization *(ii)* Fictitious domain-like methods *(iii)* High Performance Computing using thousands of processors.

This work will be done in close collaboration with physical experiments at LIPHY Lab and with the partners of the Vivabrain project. It requires specific skills in numerical analysis and high performance computing and also openness to other disciplines such as physics and medicine. It is a continuation of the thesis of Vincent Doyeux (defense scheduled for late 2013) and that of Vincent Chabannes (defense scheduled for April/May 2013) supervised by M. Ismail and C. Prud'homme. Indeed, in the first thesis we are interested in modeling blood red cells by vesicles and in the second thesis, the goal was to develop numerical methods taking into account the fluid/structure interaction at the walls arteries.