MatComPhys : Mathematical Models and High Performance Computing for Deposition and Absorption in Physiological Flows

Description

The project involved the development of mathematical models and their implementation as software code for high performance computing clusters. The physical problem studied involves two related topics: particle deposition and solute absorption in respiratory airways, and tumour metastasis in arterioles and capillaries. The aim was to couple micro-scale phenomena to large 3D incompressible flow simulations. These topics were chosen for their clinical relevance and complex, coupled nature that requires large-scale computing.

The numerical tools developed were twofold, namely 1D geometric multi-scale networks and Lagrangian mesh-free schemes. The 1D models served as fluid boundary conditions of the main conduit, and represented the vascular bed in the tissue. The 1D models were based on Cosserat director theory. A Lagrangian mesh-free scheme was used to model the multi-component fluids (whole blood and particle-laden air). This approach enabled coping with multi-body interactions and the deformation of the corpuscles; hence it modelled the micro-scales and interfaced with existing incompressible solver at the host institution. The Lagrangian mesh-free method was based on radial basis function and point interpolation schemes.

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