

RESEARCH TOPIC FOR THE PARISTECH/CSC PhD PROGRAM

Field: Materials Science, Mechanics, Fluids

Subfield: Mechanical Engineering / Biomedical Engineering

Title: Numerical and Experimental Study of Liquid Plugs in Human Lungs

ParisTech School: Arts et Métiers Sciences et Technologies

Advisor(s) Name: Francesco Romanò, Amir Bahrani, Michaël Baudoin

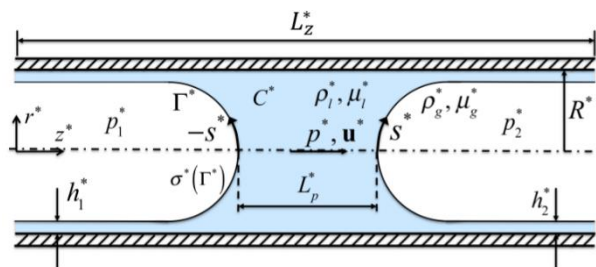
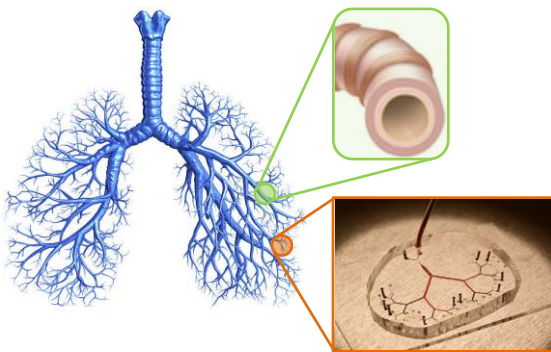
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Research group/Lab: Laboratoire de Mécanique des Fluides de Lille (LMFL)

Lab location: 8 bd Louis XIV - 59046 LILLE Cedex

(Lab/Advisor website): <http://lmfl.cnrs.fr/en/home/>

Short description of possible research topics for a PhD: The airways are lined with a bi-layer annular liquid film consisting of mucus (elastoviscoplastic liquid) and serous layer (weakly viscoelastic liquid). When the film thickness is too high, liquid plugs can form preventing distal air exchange in human lungs. Such liquid plugs are typically observed among patients affected by chronic pulmonary pathologies (CF and COPD), and by respiratory diseases such as Covid-19. The aim of this project is to unravel how viscoelastic and viscoplastic effects interact, depending on the interplay between the three phases. This project further aims at studying the effect of deformability of the airway walls and, finally, to test the impact of surfactant replacement medical therapies. Numerical simulations will be carried out using the multiphase finite-difference/front-tracking in-house code developed by F. Romanò at Arts et Métiers, Lille [2]. Experiments will be carried out at IMT Lille Douai and IEMN under the supervision of A. Bahrani and M. Baudoin, respectively. Special attention is paid to the mucus rheology, experimentally reproduced by synthetic liquids, and to the liquid plug dynamics, characterized by flow visualization and μ PIV in rigid or flexible capillary pipes. Finally, numerical simulations and experiments will be compared.



Required background of the student: Fluid Mechanics or Applied Mathematics

A list of 5 (max.) representative publications of the group:

1. Y. Hu, F. Romanò, J. B. Grotberg, J. Biomech. Eng., 142 (2020) 061007.
2. M. Muradoglu, F. Romanò, H. Fujioka, J. B. Grotberg, J. Fluid Mech., 872 (2019) 407–437.
3. F. Romanò, H. Fujioka, M. Muradoglu, J. B. Grotberg, Phys. Rev. Fluids, 4 (2019) 093103.
4. M. Baudoin, Y. Song, P. Manneville, C. N. Baroud, Proc. Nat. Ac. Sci., 110 (2013).