ECOLE DOCTORALE
ED 468
« Mécanique, Energétique, Génie Civil, Procédés »

Thesis proposal for a Doctoral position (Contrat Doctoral 2021-2024)
Mention : Fluid Dynamics

Deadline for application to Doctoral School MEGEP : May 7 2021
Candidates should send a CV and cover letter to S. Lorthois and F. Risso before April 7 2021

Title	Flows of red blood cells in micro-channel networks: non-local effects and interactions with white blood cells.
Supervisor	LORTHOIS Sylvie Home institution : INPT Email : sylvie.lorthois@imft.fr
Second Supervisor	RISSO Frédéric Home institution : INPT Email : Frederic.Risso@imft.fr
Laboratory	Institut de Mécanique des Fluides de Toulouse
Administrative aspects	Doctorate in France : see https://www.campusfrance.org/en/FAQ-Doctorate-France-questions The selected candidate will be hired by Toulouse-INP, and will be offered the full pack Toul'Box (see https://toulbox.univ-toulouse.fr/en/packages/student)

Research project description : This subject is a continuation of the experimental work carried out during the theses of S. Roman (2009-2012) and A. Merlo (2014-2018). During these theses, we set up the experimental tools to finely characterize red cell flows, from the scale of the micro-channel to the scale of the network, in large ranges of confinement (C = 0.5 to 2) and of volume fraction (H = 0 to 25%) [1]. The associated experimental and theoretical developments have made it possible to propose a simple parametric model of the concentration and velocity profiles of red blood cells, which makes it possible to explain all the results available in the literature on red blood cell concentration heterogeneities downstream of bifurcations (phase separation effect [2]). With regard to networks, we have shown that, depending on the flow regimes associated with these two parameters, the asymmetry of red blood cells downstream of these bifurcations can have a major impact on their distribution at the network level (left figure). Preliminary results on the relaxation of red blood cells towards the center of the canal were obtained in a limited range of parameters (right figure). In this range, these results explain the distribution of red blood cells at large scale.

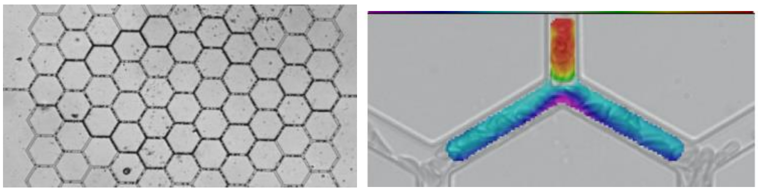

Figure : Left *: Heterogeneities of RBCs in a microfluidic network.* ***Right*** *: Velocity field (colors) superimposed to RBC visualization downstream the first network bifurcation.*

The first objective of this thesis is to conduct a systematic study of this relaxation, for a wide range of parameters, and to understand its impact at the network level. The second objective is to understand how these phenomena interplay with disturbances caused when defects, such as occlusions, are present in the network. In this case, the results of our numerical simulations suggest that flow temporal variations, including changes in direction, could occur. Finally, the third objective is to look at the effects of the presence of a small proportion of larger and more rigid cells, white blood cells, that can be viewed as transient occlusions or slowing of flow. In addition to a great physical wealth, the fundamental results that will be obtained should help to better understand the importance of these phenomena during the early stages of Alzheimer's disease [3].

References : 1. Roman et al., 2012. Velocimetry of red blood cells in microvessels by the dual-slit method: Effect of velocity gradients. *Microvascular Res*. **2.** Roman et al. 2016. Going beyond 20 μm-sized channels for studying red blood cell phase separation in microfluidic bifurcations. *Biomicrofluidics*. **3.** Cruz Hernández, […], Lorthois, Nishimura, and Schaffer. 2019. Capillary occlusions reduce cortical blood flow and impair memory in Alzheimer's mouse models. *Nature Neuroscience*.