Université de Technologie de Compiègne – Thesis proposal

Part 1: Scientific sheet	
Thesis proposal title	**Modeling of microcapsules flowing in a multi-bifurcated network** Modélisation de microcapsules en écoulement dans un réseau multi-bifurqué
PhD grant	Financed by **Sorbonne Université**
Research laboratory	*Laboratory*: Biomechanics & Bioengineering Laboratory (UMR CNRS-UTC 7338), UTC Compiègne *research team*: Biological Fluid Structure Interactions *web site*: http://www.utc.fr/~salsacan/
Thesis supervisor(s)	Dr Anne-Virginie Salsac, DR CNRS (HDR), BMBI, UTC (Compiègne, France) Dr José-Maria Fullana, Prof (HDR), Institut Jean Le Rond d'Alembert, Sorbonne Université (Paris, France) Dr Florian de Vuyst, Prof (HDR), LMAC, UTC (Compiègne, France)
Scientific domain(s)	Science and technology Biomedical and health science engineering *EURAXESS fields*: Biomedical Engineering, Mechanical Engineering, Simulation Engineering, 3D Modelling, Modelling Tools, Computational Mathematics
Research work	Micro-capsules, which are fluid droplets enclosed in a thin elastic membrane, are current in nature (red blood cells, phospholipidic vesicles) and in various industrial applications (biotechnology, pharmacology, cosmetics, food industry). They are used to protect and transport active principles, by isolating them from the external suspending fluid. One application with high potential is the use of microcapsules for active substance targeting. But, once injected in the blood flow, the behaviour of the particles is not fully understood. The microcapsules are indeed subjected to large deformations, because of the strong interactions in the flow, but these strongly depend on the vessel network. There is currently a lack of understanding of the distribution of deformable microparticles in a complex bifurcated network. The objective of the project is to study the flow of a dilute suspension of capsules flowing in a capillary network composed of bifurcations in cascade. Their flow and deformation will be modeled numerically with Capsilisk, a numerical code that we have recently developed by coupling the Finite Element solver of Caps 3D with Basilisk (a Finite Volume code) using a Boundary Immersed Method. The goal will first be to optimize the code (ex: parallelization) and set up simulations in bifurcations made of one inlet and several outlets. A database will be generated by changing consistently the geometry of the network and the properties (size and resistance) of the capsules. The last objective of the project will be to build reduced order models using physics-based artificial intelligence techniques in order to predict the capsule distribution in the network in real time.
Key words	Microcapsules, bifurcated network, fluid-structure interaction, numerical simulation, parallelization, reduced-order models
Requirements	*Skills*: - Strong scientific background in solid and/or fluid mechanics and in scientific computing - Notions of biomechanics/bioengineering and in code parallelization will be a plus - Proficiency in English and in French if possible - Excellent interpersonal and communication (written and verbal) skills

	Personal Qualities: - Ability to work collaboratively as part of a team in an interdisciplinary context - Capacity to conduct a project with different tasks and respect deadlines - Flexibility, motivation, pro-activity, commitment to high quality - Commitment to continuous educational and professional development - Commitment to UTC's and CNRS' policy of Equal Opportunity, ability to work harmoniously with colleagues and students of all cultures and backgrounds *Qualification*: MS degree or equivalent qualification.
Starting time	Fall 2020
Location	BMBI Laboratory, UTC

Funding/Cofunding or/and partnerships:

☐ **Région Hauts de France (cf dossier)**
☐ **Labex**
☐ **Ecole doctorale**
☐ **Partenariat industriel**
☒ **Autre (préciser)** Sorbonne Université

Part 2: Job description	
Duration	36 months
Additional missions available	
Research laboratory	The project will take place within the 'Biological Fluid-Structure Interactions' Group, directed by A.V. Salsac, which is one of the 3 research teams of the UTC Biomechanics & Bioengineering Laboratory (http://www.utc.fr/bmbi/). The group is specialized in the fields of biofluids and hemodynamics at both the microscopic and macroscopic scales. It focuses on the study of the fluid-structure interactions that occur between fluid flows and various flexible structures (vessel wall, capsule and cell membrane, biomedical devices, etc.). The strength of the group is the long expertise in numerical modeling of artificial capsules with the boundary integral method. The group has the unique characteristic of combing numerical and experimental expertise, which enables to translate theoretical results into practical applications. They have developed microfluidic techniques to produce and characterize microcapsules, as well as study their deformation when they flow in micro-tubes and networks. http://www.utc.fr/~salsacan/ The project will be conducted in collaboration with Jean Le Rond d'Alembert Institute (IJLRA) from Sorbonne Université and Compiègne Laboratory of Mathematics (LMAC) from UTC. - Jose-Maria Fullana, who will co-supervise the PhD, has a very large expertise in numerical methods for two-phase flows. With the team, they develop an « open source » software (Basilisk) designed for interfacial flows (drops, bubbles, waves) in complex configurations, and in which the Navier-Stokes equations are solved on a cartesian grid with the Finite Volume Method. http://www.lmm.jussieu.fr/~fullana/ - Florian de Vuyst, who will be co-advisor supervise the PhD, is an expert in numerical modeling in Fluid Mechanics and engineering, with special focus on model-order reduction. He is specialized in the development of numerical tools to model complex multiphysics problem in mechanical engineering, correlate experiments and numerical simulation and optimize large-scale problems using reduce-order approaches. https://fdevuyst.jimdo.com/
Material resources	All of the tools and equipment needed for the project are available in the 'Biological Fluid Structure Interactions' team of BMBI, IJLRA and LMAC Laboratories: For the numerical simulations: - Fluid-structure simulation codes based on the coupling between Basilisk (Finite Volume Method) to solve for the fluid flows and Caps3D (Finite Element Method) for the capsule wall deformation - Workstations, High Performance Computing facilities
Human resources	The BMBI laboratory is composed of about: - 40 permanent staff members (27 academic staff, 13 technical and administrative staff) - 31 PhD students - 8 Postdocs - 7 associated researchers - 15 Master students
Financial resources	The environmental costs will be supported by the MultiphysMicroCaps project, financed by ERC, which is a large project that explores the use of deformable liquid-core capsules of micrometric size to efficiently transport active material, with a primary focus on health-related applications. It is focused on the design of

	innovative sophisticated numerical models and high-tech experiments, needed to determine the potential of such vectors for the protection of active substances, predict membrane breakup to control the delivery, and optimize their properties for specific industrial and biomedical applications.
Working conditions	What is expected from the candidate is to have a sense of autonomy and to be capable to work in group. His/her mission will be to conduct the research project, present his/her results during the research meetings (meetings with the advisors, lab meetings, etc) and to the rest of the scientific community via publications in international journals and conferences.
Research project	
National collaborations	- Solid Mechanics Laboratory, Ecole Polytechnique - INRIA Paris Institute
International collaborations	- School of Engineering and Materials Science, Queen Mary University of London (UK)
International cosupervision (cotutelle)	
Contact	To apply please send a complete CV, a letter of motivation, 2 letters of recommendation or the contact details of 2 referring persons, as well as the result transcripts for all the courses followed at university to: Dr Anne-Virginie Salsac (a.salsac@utc.fr) BMBI Laboratory (UMR CNRS-UTC 7338) UTC CS 60319 60203 COMPIEGNE cedex, France Prof José Maria Fullana (fullana@lmm.jussieu.fr) Institut Jean le Rond d'Alembert (CNRS UMR 7190) Sorbonne Université Boîte 162, Tour 55-65 4 place Jussieu 75252 Paris Cedex 05, France Prof Florian de Vuyst (florian.de-vuyst@utc.fr) LMAC Laboratory UTC CS 60319 60203 COMPIEGNE cedex, France Please note that only candidates who have been shortlisted will be contacted

Please contact first the thesis supervisor before applying online on https://webapplis.utc.fr/admissions/doctorants/accueil.jsf