

Université de technologie de Compiègne – Thesis proposal

Part 1: Scientific sheet	
Thesis proposal title	Rheology of Soft Particles: Interplay Between Particle Deformability and Inter-Particle Forces
PhD grant	ANR (Agence Nationale de la Recherche)
Research laboratory	Laboratoire Biomécanique et Bioingénierie (BMBI) research team: Biological Fluid-Structures Interactions (IFSB) web site: https://bmbi.utc.fr
Thesis supervisor(s)	Badr Kaoui, CNRS Associate Scientist, HDR https://sites.google.com/site/bkaoui/ Marc Leonetti, CNRS Senior Scientist, HDR
Scientific domain(s)	Biology, biomedical and health sciences Sciences pour l'ingénieur
Research work	<p>The behavior of soft particles in flow presents significant challenges, particularly in controlling their dynamics for various applications. This project focuses on fluid-filled soft particles enclosed by a thin, deformable membrane, commonly known as capsules. For the first time, we aim to explore how inter-particle chemical and physical forces at the microscale influence the macroscopic rheology of suspensions. This research falls within the broader field of complex fluid dynamics and has numerous applications in biology, the food industry, environmental sciences, and pharmaceuticals. While our team has extensively studied the dynamics of soft particles under different flow conditions, inter-particle forces have not yet been incorporated into our models or computer simulations.</p> <p>In both natural (e.g., red blood cells) and artificial soft particle systems, inter-particle interactions stem from various chemical and physical mechanisms, including adhesion, friction, and electrostatic forces. However, their effects on particle flow remain largely unexplored. Experimental studies on rigid particles have demonstrated that adhesive interactions can lead to aggregation, accumulation, and adhesion to channel walls. This project aims to investigate similar phenomena in soft particles, systematically varying their deformability and the strength of inter-particle forces.</p> <p>The goal of this PhD project is to develop new theoretical models for inter-particle forces and integrate them into our in-house library. Our existing code enables fully three-dimensional simulations of multiple soft particles in flow, incorporating two-way fluid-structure interactions. Through a series of simulations, we will test and validate the extended model in collaboration with experimental researchers who will synthesize capsules and characterize their rheology.</p>
Key words	Soft Particles, Rheology, Inter-particle Interactions, Computer Simulations
Requirements	MSc or MEng in Computational Physics, Applied Mathematics, Mechanical or Chemical Engineering
Starting time	October 1st, 2025
Location	Université de Technologie de Compiègne, Compiègne, France

Part 2: Job description	
Duration	36 months
Additional missions available	Teaching at the UTC
Material resources	Powerful work station and access to local, national and European High Performance Computing facilities
Human resources	A research team with long-standing experience in scientific computing for biological soft matter systems.
Financial resources	SOCA - Suspensions of SOF Capsules (ANR-24-CE06-6245-02)
Working conditions	Weekly meetings
Research project	SOCA - Suspensions of SOF Capsules (ANR-24-CE06-6245-02)
National collaborations	Dr. Marc Leonetti, Marseille, France
International collaborations	Prof. Jens Harting, Erlangen, Germany
Contact	Send detailed CV, cover letter, at least two recommendation letters, and any other documents supporting the application by email to Badr Kaoui: badr.kaoui@utc.fr

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