Please use the following format for the title of the file so as to ease the management of the web site.

ECM_M2P2_ JAEGER_ 01

PhD Proposal 2017

School: Ecole Centrale de Marseille	
Laboratory: M2P2	**Web site: http://www.m2p2.fr/recherche-m2p2-19/technopole-chateau-gombert-155/procedes-et-mecanique-aux-petites-echelles-29/**
Team: Process and mechanics at microscale (M2P2)	**Head of the team: Marc Jaeger (M2P2)**
Supervisor: Marc Jaeger	**Email: marc.jaeger@centrale-marseille.fr; gang.chen@univ-amu.fr**
Collaboration with other partner during this PhD: **In France: Marc Leonetti (IRPHE)**	**In China:**

Title: New numerical schemes for active fluid-microcapsule interaction
Scientific field: Fluid mechanics, applied analysis, numerical computations
Key words: capsule, fluid-structure interactions, membrane, drops, microfluidics

Details for the subject:

(Maximal length of 2 pages, including images, list of reference, ...The pdf file should not exceed 1Mo)

Background, Context:

Microcapsules are drops bounded by a thin shell called membrane. There is a tremendous research on this kind of deformable particle due to their biocompatibility and biodegradibility providing applications in nutrition, cosmetics, pharmacology, flavor industry if they contain drugs... They are also models to mimic the motion of red blood cells in blood vessels. Understanding their behaviour in flow or under stress is essential because of stress-induced drug delivery in the environment. Numerous pathologies have also an hydrodynamic signature which is not explained.

All these deformable microcapsules are embedded in a viscous fluid which is in the regime of Stokes flow (no turbulence). This problem could seem simple but in fact reveals a scientific challenge in many configurations such as already evoked due to the long range many-capsule hydrodynamic interactions questioning how complexity emerges from the motion of soft particles. With a more concentrated suspension, microcapsules are closer and the contribution of lubrication film dissipation becomes crucial. In this case, the two difficulties are how to compute efficiently the contribution of long range interactions between many soft particles and short range between neighbouring ones.

Another kind of behaviour is expected when soft particles are the site of active chemical reactions, active means that the system is out of thermal equilibrium. For example, the consumption of ATP (chemical energy) which is transferred in mechanical energy allows bacteria to move with flagella beating, cells to explore their environment through crawling, droplets (interfacial reaction) to move.

We propose to study numerically suspensions of active biomimetic soft particles and their rheology, it means “how it flows ?”

Research subject, work plan:

A preliminary work plan can be declined as follows:

1. Bibliography and state of the art
2. Understanding Stokes flow and involvements on fluid-microcapsule interactions on several examples
3. Taking in hand our numerical code dedicated to the motion of a single deformable particle such as vesicle, capsule and polymersome.
4. Development of a new scheme to deal with two and more capsules under a simple flow.
5. Parametric studies
6. PhD thesis redaction

Recent references on the problematics :

- J. Gounley, G. Boedec, M. Jaeger and M. Leonetti, *Influence of surface viscosity on droplets in shear flow*, J. Fluid Mech. **791**, 464-494 (2016)
- A. Guckenberger, M. Schraml, P. G. Chen, M. Leonetti and S. Gekle, *On the bending algorithms for soft objects in flows*, Computer Physics Communications **207**, 1-23 (2016)
- C. de Loubens, J. Deschamps, F. Edwards-Lévy et M. leonetti, Tanktreading of microcapsules in shear flow, J. Fluid Mech. **789**, 750-767 (2016)
- R. Trozzo, G. Boedec, M. Leonetti and M. Jaeger, Axisymmetric Boundary Element Method for vesicles in a capillary, J. Comp. Phys. **289**, 62-82 (2015)

- C. de Loubens, J. Deschamps, G. Boedec and M. Leonetti, *Stretching of capsules in an elongation flow, a route to constitutive law*, J. Fluid Mech. **767**, R3 (2015).
G. Boedec, M. Jaeger et M. Leonetti, *Pearling instability of a cylindrical vesicle*, J. Fluid Mech. **743**, 262-279 (2014)
- C. de Loubens, J. Deschamps, M. Georgelin, A. Charrier, F. Edwards-Lévy and M. Leonetti, *Mechanical characterization of cross-linked serum albumin microcapsules*, Soft Matter **10**, 4561-4568 (2014)