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PHYSIQUE – CHIMIE INGENIERIE	NANOSCIENCES – PHOTONIQUE – SCIENCES DES MATERIAUX & CARACTERISATION

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PhD subject in CSC program

1. **Title** : Numerical meshless method dedicated to impact mechanics on soft materials.

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4. **Description of the subject** :

Numerical simulations are interesting ways to investigate physical phenomenon and also to avoid costly experimental device. In a mechanical framework, it allows predicting the bebaviour of a mechanical structure under severe loadings, and access to data which can be difficult to observe during experiments. As an example, numerical simulations like finite element methods are widely used for the understanding of high speed dynamics phenomenon such as impact mechanics. However, there are some limitations in the use of classical methods such as large distorsion of the mesh which could be solved for instance with particular methods (Element Free Galerkin or Smooth Particles Hydrodynamics). These methods have proven their efficiencies in the context of solid

mechanics, but also in the context of biomechanics and soft tissue damage. Indeed, in the latter framework, the SPH method has been used to simulate impacts in soft tissues. An example of this concept is illustrated in figure 1 showing a SPH model of a soft tissue surrogate sample at a microscopic level.

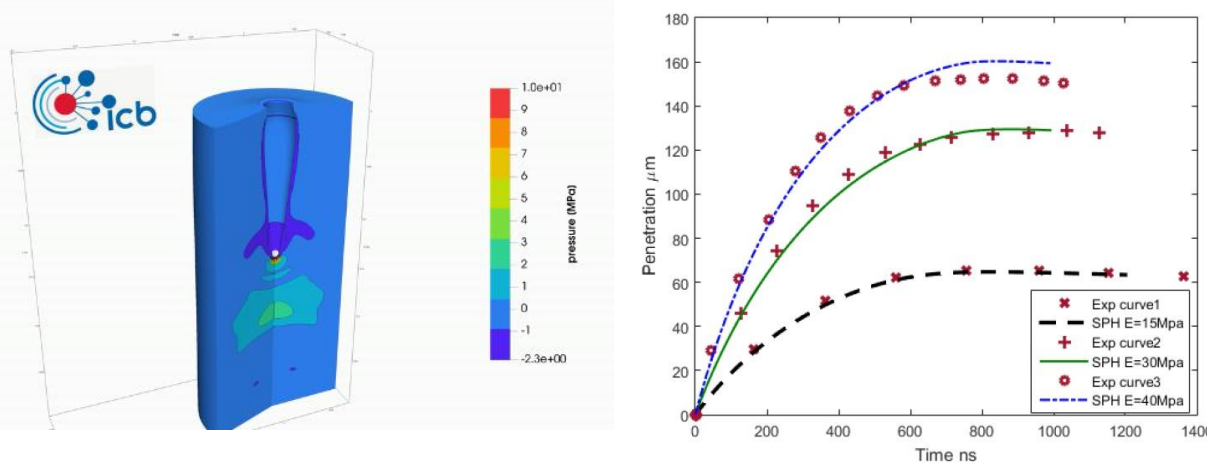

Figure 1 : trajectory of a microscopic sample and mechanical interaction with a soft tissue

The coupling of biomechanical simulations and meshless theories is a very interesting and promising task, and the PhD student will have to investigate and achieve several topics linked to impact mechanical engineering, biomechanics, and also numerical theories of Smoothed Particles Hydrodynamics methods:

- Realistic constitutive laws have to be developed and implemented in the biomechanical models (such as biological soft tissues) with appropriate mechanical parameters. Visco-elastic, hyperelastic, hydrodynamic laws, or combinations of all, have to be studied, and validation have to be conducted against experimental data of the literature considering impact problems for both microscopic and macroscopic levels.
- The use of Smoothed Particles Hydrodynamics methods should be used to simulate the perforation of a projectile in a soft material in a context of damage mechanics. Investigation on the calibration of the method, investigation of the effects of numerical parameters on the results will be studied. Alternative formulations such as the transformation of finite elements into particles when the deformation is too high, can also be considered.
- Commercial codes such as Radioss can be used. If we notice limitations of the commercial code, the PhD student can use an “in-house” code already developed in the lab, and simulate reference perforating cases of the literature.

Finally, this PhD thesis deals with the development of numerical theories of meshless methods, to be implemented in biomechanical numerical models to simulate perforating impacts.

5. **references** :

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