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2 Opened PhD positions in polymer physics

- **AFM measurements on glass transition in polymer thin films**

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The glass transition is an ubiquitous phenomenon, both in nature, and in practical and technological processes. Understanding the mechanisms involved in the glass transition is an important scientific challenge, not only from a fundamental point of view regarding the glass transition itself, but also because the glass transition plays a key rôle in very important issues such as adhesion, preparation of good damping materials, toughening of polymeric materials,and reinforcement of filled elastomers.

The general objectives of the proposed research project is to perform mechanical measurements at small scales by atomic force microscopy (AFM) in highly confined polymer around Tg. The theoretical motivation of this work is that studying confined glass-forming systems is a promising technique to investigate the existence of a cooperative length for glass transition dynamics. More precisely, we will study different systems in which the confinement effects can create huge changes in the mechanical properties of the systems using a specialy designend AFM with Shear Modulation Force Microscopy capability.

- We want to study the effect of the film thickness to compare direct measurements to indirect measurement such as dielectric measurements or thermal expansion measurements as a function of the film-substrate interactions, as a function of the explored degree of freedom...
- We want to study the effect of this confinement on the aging properties of thin polymer films.

Since confinement effects could explained some remarkables properties of nanostrucured materials, this will lead to a study of:

- the mechanical properties of the polymer at the nanoscale closed to the solid particles as a function of the distance to the particle in filled elastomers,
- mechanical properties at the nanoscale in yielding polymers.

The phD student will be inserted in the so-called "Pôle Polymer", which is a group including theoreticians and experimentalists, working together on the microscopic aspects of the glass transition.

- **Fracture propagation in reinforced rubbers: a theoretical and numerical study**

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Reinforced elastomers exhibit unique physical properties. Whereas the non-reinforced rubbers have a low resistance to tear and wear, reinforced elastomers can be used under very demanding conditions. These systems have been of interest for scientists over the past 50 years, but until recently progress have been slow. Recent progress regarding the glass transition mechanisms in the vicinity of interfaces [1] have allowed for understanding some aspects of the reinforcement, such as the high shear modulus and the dissipative properties [2]. We have developed a joint theoretical and numerical approach for describing the non-linear and plastic behavior of these systems, in the non-destructive regime of deformation [3]. The aim of this thesis is to extend these works to simulate the tear of such materials. The effects we aim at understanding are very important since the energy of tearing can be hundred of times larger than that for the non-reinforced material.

Our approaches are those of statistical mechanics and polymer physics. They involve multi-scale modeling, from one nanometer up to several hundred of nanometers, and involve also numerical simulations (dissipative molecular dynamics).

[1] Long D., Lequeux F.; "Heterogeneous dynamics at the glass transition in van der Waals liquids, in the bulk and in thin films", *EPJ E*, 4, 371-387 (2001)
[2] Berriot J., Montès H., Lequeux F., Long D. and Sotta P., "Gradient of glass transition temperature in filled elastomers", *Eur. Phys. Lett.*, **64**, 50-56 (2003)
[3] Merabia S.; PhD thesis (in preparation)