Post-doctoral position – Laboratoire Navier, France – 18 months

Project: Interaction between process zone and material heterogeneity in the toughening of adhesive interfaces.
Duration: 18 months. Starting before February 2023.
Host institution: Laboratoire Navier (ENPC, Université Gustave Eiffel, CNRS), Champs-sur-Marne, France.

Description of the project: Significant efforts have been made in the past decades to unravel the influence of material heterogeneities on the failure behavior of composites. The apparent fracture properties of brittle composites are strongly controlled by the various local failure mechanisms involved at the crack tip during the interaction of the crack with microscopic material heterogeneities. The competition between these local mechanisms, as well as their ultimate contribution to material reinforcement, is usually well-described by the Linear Elastic Fracture Mechanics (LEFM) theory.

A major pitfall of LEFM is that it does not take into account the influence of some ubiquitous spatially extended weakening dynamics near the crack tip, that can emerge from, e.g., cavitation and fibrillation in soft elastomers, crazing in polymers, micro-cracking and particle bridging in concrete and rocks. As such, no meaningful length scale associated with the failure process is taken into account in LEFM. However, in a realistic modeling of fracture in heterogeneous materials, one expect the dynamics to depend on the interplay between the material heterogeneities (of size w) and the spatially extended dissipative zones. The typical scale on which such spatially extended dissipation occurs is ℓ_{pz}, characteristic of the so-called *process zone*. The construction of a dearly missing framework to describe fracture properties in heterogeneous materials necessarily builds on a description of the failure processes around $w/\ell_{\mathrm{pz}} \sim 1$.

To fill this gap, the candidate will perform experiments of adhesive peeling of a soft elastomer from a micro-patterned interface. Imaging techniques will be deployed to monitor the failure process involved during the interaction of a peeling front with heterogeneities of adhesion of size ranging below and above the process zone. The failure mechanisms observed in the experiments and the associated toughening of the interface will be compared to that predicted by recent models developed in our group.

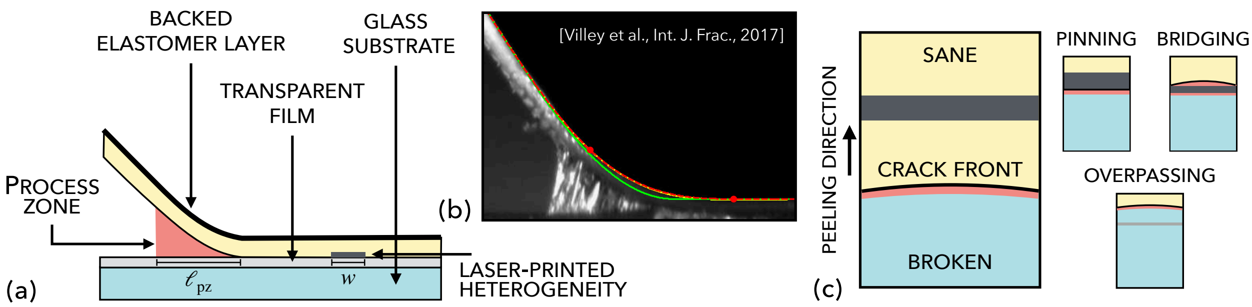

Figure 1: (a) Peeling experiments along a patterned interface: a soft elastomer layer is peeled from a glass substrate, on top of which is glued a transparent film covered by laser-printed heterogeneities. (b) The process zone, associated with fibrillation of the polymer layer, is of the order of $200\mu\mathrm{m}$ (after (Villey et al., Int. J. Frac., 2017)). (c) Depending on the width w of the barrier with respect to the process zone size ℓ_{pz} of the interface, one expects a transition from crack pinning to barrier breaking, passing by a bridging phase.

Key requirements: Ph.D. in Physics or Mechanical Engineering, or in another relevant Solid Mechanics discipline (applicants who have submitted their PhD thesis and are awaiting their PhD award are also encouraged to apply). Experience in experiments of adhesion or fracture of polymers is required.

Application: Interested candidates should contact the postdoc advisors: Gwendal Cumunel (gwendal.cumunel@enpc.fr), Mathias Lebihain (mathias.lebihain@enpc.fr), and Julien Léopoldès (julien.leopoldes@univ-eiffel.fr). Please provide an updated CV and one/two reference letters.

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