Statistical organization of microfracturing events uncovering brittle crack propagation in disordered solids: From slow to fast crack propagation regime.

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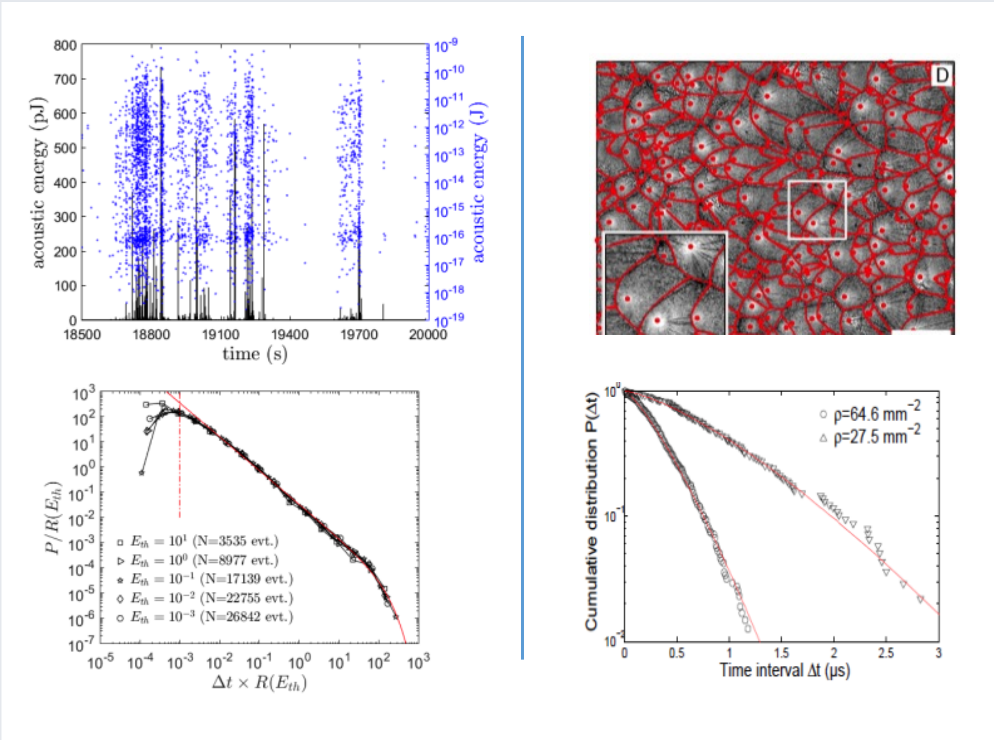
Crack propagation is the basis mechanism responsible for material failure. Still, its understanding and description have been only partially succesfull: Stress enhancement at the crack tip makes the the growth dynamics observed at the macroscopic scale extremely depedent of the microstructure disorder down to very small scales. This translates into a difficult problem for material evaluation and design due to large seemingly random fluctuations incompatible with the determinism paradigm of engineering approaches.



We first looked [1] at how microfracturing events get organized as a crack is slowly driven (at speed ~μm/s) in an artificial rock obtained by sintering polymer beads (left part of the figure). Acoustic emission was recorded and analyzed to determine this organization (upper left figure). The acoustic events were observed to exhibit a self-similar time-energy statistics (lower left figure) reminiscent of that of earthquakes. In particular, the standard seimic laws for aftershock commonly used in the proabilistic forecasting models of earthquakes (Omori-Utsu law being the most famous one) were recovered [1]. This scale-free organization can be qualitatively understood using tools from non-linear physics (the paradigm of the depinning transition of elastic manifolds) whichh invoke the interplay between localized disorder and long-range elastic interactions. We then looked [2] at the microfracturing dynamics in the fast dynamics regime, with cracks propagating at at speeds ~100-500 m/s in polymethylmethalcrylate --PMMA (right part of the figure). It is there the quantitative analysis of the post-mortem fracture surfaces that allowed us to reconstruct with micrometer/nanosecond resolution the full microdamaging dynamics. The statistics then stops being scale-free and distributions reminiscent of extreme events statistics are observed (Weibull statistics for Inter-event time, see lower right figure). This is interpreted as a consequence of the long-range elastic interaction between events to stop being active due to the speed at which the system evolves.

Ongoing work aims at characterizing the role played by the elastic wave emitted and selected in these fast fracture regimes, and further understanding the nature of the so-induced elastic interaction.

[1] J. Barés, A. Dubois, M.L. Hattali, D. Dalmas, D. Bonamy, *Aftershock sequences and seismic-like organization of acoustic events produced by a single propagating crack*, Nature communication (in revision)

[2] A. Dubois, C. Guerra, J. Scheibert, D. Bonamy, D. Dalmas, *The near-tip microfracturing dynamics of fast cracks* (in preparation)

Résultats obtenus dans le cadre du projet TURB&CRACK financé par le thème 2 du LabEx PALM et porté par Daniel Bonamy et Sebastien Aumaitre (SPEC).