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Quenched versus thermal disorder in crack propagation: size (and scales) matter.

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The slow propagation of crack in heterogeneous material is of fundamental importance for the failure of engineering structure and of natural system, such as seismic faults. Owing to the many interacting processes at play, it however still remains a challenge to describe the precise mechanical formulation that governs the dynamics of such systems. Previous studies dedicated to this issue have mostly been restricted to the zero temperature limit, giving rise to extremal dynamics, or to systems with short range interactions. Here we incorporate in a numerical model of slow crack growth the effect of temperature and long range elastic interactions. This approach provides a more realistic model of crack propagation in heterogeneous media under natural conditions. We adopt the configuration of an interfacial crack system, similar to a designed experimental setup. We recover both at the macroscopic and at the microscopic scales all the reported experimental observations. Namely we are able to observe a similar macroscopic crack evolution, a similar morphology of the crack front line and a similar distribution of local speeds: a self affine morphology with roughness exponent around 0.5 at small scale, and a lower effective roughness at larger scale for the front morphology [1], and a non Gaussian power law velocity distribution, with a fat tail $P(v)\ v^{-}2.6$ at large speeds [2,3].

We also evidenced the competition between temperature and disorders, influencing the crack dynamics and modifying the crack pattern. We present analytical derivations that independently recover our numerical and experimental findings of two regimes dominated at small [4] and large scales [5] by quenched and annealed disorders respectively. We demonstrate that the cross-over length between these two regimes varies with the inverse of the temperature. We also show that the distribution of local speeds in our system is controlled by a parameter which depend both on temperature and disorder fluctuations. We finally discuss the implications of these results in terms of fault mechanics.

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