Nonlinear effects on crack propagation and interaction

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The observed repulsive behaviour of two initially collinear cracks growing towards each other and leading to a hook-shaped path questioned recently the validity of the Principle of Local Symmetry within Linear Elastic Fracture Mechanics theory [1]. Theoretical and numerical work has solved this dilemma, providing the precise geometric conditions for the existence of the repulsive phase and revealing a multi-scale behaviour of the repulsive/attractive transition [2]. However, in polymer films, the repulsive phase depends strongly on the microscopic behaviour of the material, highlighting the crucial role of the fracture process zone [1]. At interaction distances larger than the process zone size, microscopic shape of the process zone tip controls crack repulsion. The maximum angle of repulsion is then systematically smaller than the one predicted by linear elasticity [2].

Nonlinear elastic materials such as elastomers also depart from the prediction of linear elasticity for interacting cracks. We performed experiments on PDMS film that indeed show a maximum angle of repulsion not only significantly smaller than the one of linear elasticity, but also smaller than the one observed in polymer films with a plastic process zone. Our FEM simulations on a Mooney-Rivlin material confirm that the nonlinear elastic response of PDMS modifies the crack path, reducing the repulsive strength between the two interacting cracks.

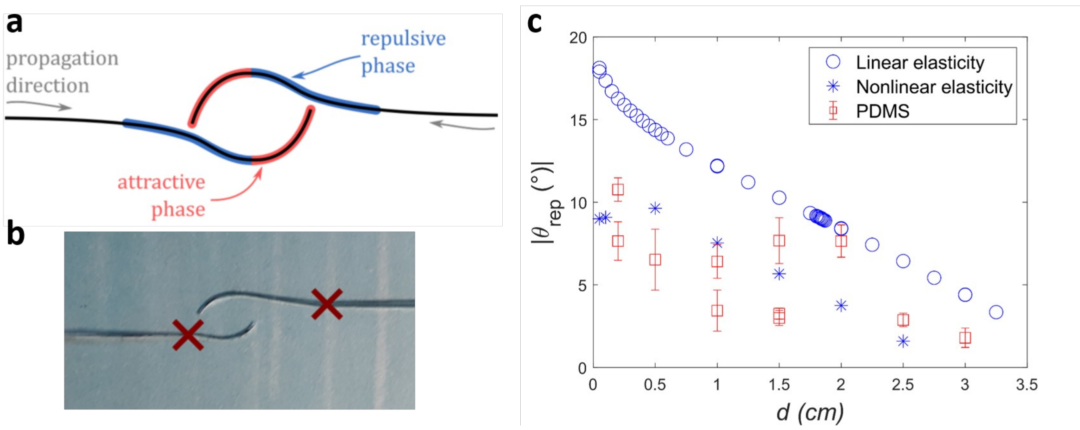

Figure 1. a. Repulsive and attractive phase (FEM). **b.** Example in PDMS film. **c.** Maximum repulsion angle in PDMS films and from FEM simulation of Mooney-Rivlin material as a function of the vertical separation of the two cracks (d=0 corresponds to perfectly aligned cracks).

References

1. M. J. Dalbe, J. Koivisto, L. Vanel, A. Miksic, O. Ramos, M. Alava & S. Santucci, *Phys. Rev. Lett.*, **114**, 205501 (2015).
2. M.-E. Schwaab, S. Santucci, T. Biben, A. Gravouil & L. Vanel, *Phys. Rev. Lett.*, **120**, 255501 (2018).