DYNAMICAL FRACTURE INSTABILITIES DUE TO LOCAL HYPERELASTICITY AT CRACK TIPS

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Abstract:

Cracks moving at low speeds create atomically flat mirror-like surfaces, whereas cracks at higher speeds leave misty and hackly fracture surfaces [1]. This change in fracture surface morphology is a universal phenomenon found in a wide range of different brittle materials. The underlying physical reason of this instability has been debated over an extensive period of time. Most existing theories of fracture assume a linear elastic stress-strain law. However, the relation of stress and strain in real solids is strongly nonlinear due to large deformation near a moving crack tip, a phenomenon referred to as hyperelasticity [2]. Using massively parallel large-scale atomistic simulations [2], we show that hyperelasticity can play a governing role in dynamical crack tip instabilities in fracture of brittle materials [3]. We report a generalized model that treats the instability problem as a competition between different instability mechanisms controlled by local energy flow and local stress field near the crack tip [3]. One of the predictions of our model is the existence of stable intersonic cracks, a phenomena in clear contrast to any existing theory. It can only be understood from a hyperelasticity point of view. Our results help to explain several controversial experimental and computational results.

References:

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