Rapid crack propagation in disordered brittle solids

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Understanding dynamic fracture in brittle solids is a fundamental aspect of materials science, with implications for engineering, geophysics, and advanced manufacturing. Linear Elastic Fracture Mechanics (LEFM) provides the relevant framework to evaluate quantitatively the mechanical energy flux released to the tip of a growing crack and subsequently to predict fracture speed [1]. Still, observations revealed different instabilities occurring at high speed, which render the problem more complex. In particular, it has been observed in amorphous polymers [2, 3] that crack growth can suddenly switch from a slow-speed regime (<cm/s) to a fast-speed regime (>100m/s), which cannot be explained within conventional LEFM [4].

The present research intends to shed light on this instability by experimentally studying the mode-I fracture and crack velocity that develop during the dynamic failure of brittle solids, such as polymethylmethacrylate (PMMA, classically considered the archetype of brittle amorphous materials) and artificial rocks (heterogeneous materials made of sintered glass beads). Crack speed is measured by potential drop methods, and meso-scale dissipation and damage processes are inferred from morphological analysis of fracture surfaces. The transition between the slow and fast fracture regimes will be characterized, and the role played by damage processes occurring at the fracture process zone scale will be discussed.

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