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# NEW INSIGHTS INTO A COMPLETE THEORY OF BRITTLE FRACTURE REVEALED BY THE POKER-CHIP EXPERIMENTS

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## ABSTRACT

The poker-chip experiments of Gent and Lindley [1] – in which they bonded thin disks of rubber to metal plates at both ends and applied tension – have been subject of intense investigation within the mechanics and applied mathematics community for more than 60 years. The appearance of cavities/cracks under a triaxial stress state in these experiments came to be known as cavitation. Theoretical and experimental work over the last 10 years [2] have established cavitation as a fracture phenomenon and revealed *hydrostatic strength* to be an independent material parameter.

The modeling of cavitation as a fracture phenomenon stretches the limits of the classical fracture theories for many reasons and provide insights into what is needed to construct a complete theory that can describe fracture for arbitrary brittle material under arbitrary loading. First, it emphasizes that a unified theory for nucleation and propagation of fracture is needed. Second, it shows that the nucleation of cracks can happen in regions where stress concentrates, not necessarily where the strain energy concentrates. Third, as revealed by the recent poker-chip experiments of Guo and Ravi-Chandar [3], the ratio of hydrostatic strength to tensile strength of the elastomer has a profound impact on where and when the cracks nucleate.

To address these challenges, we have recently put forth a complete theory of brittle fracture – regularized, of phase-field type generalizing the work of Bourdin et al. (2000) – that can model the nucleation and propagation of fracture in elastomers undergoing arbitrarily large quasistatic deformations. The theory of Kumar et al. [4, 5, 6] posits that nucleation of fracture: (i) in the bulk is governed by the strength surface of the elastomer (and not just uniaxial tensile strength), (ii) from large pre-existing cracks is governed by the Griffith competition between its bulk elastic energy and surface fracture energy and is same as propagation, (iii) from boundary points, be them smooth or sharp, and small pre-existing cracks is governed by the interaction among the strength surface, the bulk elastic energy, and the surface fracture energy of the elastomer. These ingredients are integrated in a phase-field framework which results in a set of two partial differential equations that completely define the fracture process.

In this talk, we quantitatively analyze the poker-chip experiments of Gent and Lindley and Guo and Ravi-Chandar and showcase the theory's ability to describe and explain experimental observations.

## REFERENCES

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