Exactly solvable model for crack propagation in viscoelastic sheets: How to control a velocity jump leading to catastrophic failure
NAOYUKI SAKUMICHI, KO OKUMURA, Ochanomizu University — In viscoelastic solids, discontinuous transitions in the velocity of crack propagation have experimentally been observed in a narrow range of the energy release rate by using elastomers filled with carbon black particles. Although various theoretical studies have been performed on the crack propagation in viscoelastic solids, the physical mechanism of the transition has yet to be clarified. In this study, we propose a simple model for the crack propagation in viscoelastic solids for which an exact analytic solution exhibiting the velocity transition is available for the energy release rate as a function of the crack propagation velocity. On the basis of the exact expression, we provide an existence condition of the velocity transition and simple relationships useful as guiding principles to develop tough polymer materials, elucidating the physical mechanism of the transition. Our result implies that the discontinuous transition in the crack propagation velocity is a universal phenomenon that should be observed in a broad class of viscoelastic solids. An analogy between the velocity transition of our model and conventional discontinuous phase transitions are also discussed.

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