REDUCED ORDER MODEL FOR FRACTURE PROPAGATION IN VISCOELASTIC MATERIALS FOR HIGH SPEED PROPAGATION AND SUBJECT TO STRONG NONLOCAL RESISTANCE FORCE

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Recently we proposed a simple reduced order model for fracture propagation in viscoelastic materials [1,2]. In the proposed model we described the motion of a tip in the viscoelastic material that was coupled to the motion of an infinitesimally small volume (of the order of a couple of tenth of atoms) of material in the vicinity of the tip. As the tip moves, it deforms the material creating a time dependent deformation zone ϕ. A deformation zone causes a nonlocal resistance force. The equation to describe the motion of the mass M in the direction of the crack propagation can be written as: $M\ddot{x} + \Gamma\dot{x} = k_{el}(v_0 t - x) - F_b$ where $\Gamma\dot{x}$ describes energy dissipation due to crack propagation, v_0 is the average crack propagation velocity that can be estimated from $v_t = v_0 \tan\theta$, v_t is the crack opening velocity and θ is the opening angle. The resistance force F_b was described in the framework of linear elasticity and we assumed that it decays exponentially with the distance from the tip. We approximated $F_b = \int_0^{\phi} f(\Delta z) p(\Delta z) d(\Delta z)$ where $f(\Delta z)$ is the elastic force, $f = k_{el}\Delta z$, $p(\Delta z)$ is the probability density function (the probability of surfaces being separated by the distance $\Delta z \equiv z - z_{eq}$ at any given point along the crack propagation direction, z_{eq} is the equilibrium distance between atoms) and is approximated by $p(\Delta z) = (1/\delta)\exp(-\Delta z/\delta)\Delta z$, and δ is the characteristic length of the viscous flow zone corresponding to the width of the shear band [1,2].

We will discuss the applicability of the fracture propagation model [1,2] when the average crack propagation velocity is high. We will present computational results for high-velocity crack propagation subject to very large, nonlocal resistance force and will examine variety of constitutive stress-strain relations employed for high velocity propagation.

1. Y. Braiman and T. Egami, *Transitions from Smooth to Oscillatory Fracture Propagation in Brittle Metallic glasses*, Phys. Rev. E 77, 065101(R) (2008).
2. Y. Braiman and T. Egami, "*Nanoscale Oscillatory Fracture Propagation in Metallic Glasses*", Physica A 38, 1978-1984 (2009).