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Unleashing elastic energy: dynamics of energy release in rubber bands and impulsive biological systems MARK ILTON, University of Massachusetts Amherst, SUZANNE COX, The Pennsylvania State University, THIJS EGELMEERS, University of Massachusetts Amherst, S. N. PATEK, Duke University, ALFRED J. CROSBY, University of Massachusetts Amherst — Impulsive biological systems - which include mantis shrimp, trap-jaw ants, and venus fly traps – can reach high speeds by using elastic elements to store and rapidly release energy. The material behavior and shape changes critical to achieving rapid energy release in these systems are largely unknown due to limitations of materials testing instruments operating at high speed and large displacement. In this work, we perform fundamental, proof-of-concept measurements on the tensile retraction of elastomers. Using high speed imaging, the kinematics of retraction are measured for elastomers with varying mechanical properties and geometry. Based on the kinematics, the rate of energy dissipation in the material is determined as a function of strain and strain-rate, along with a scaling relation which describes the dependence of maximum velocity on material properties. Understanding this scaling relation along with the material failure limits of the elastomer allows the prediction of material properties required for optimal performance. We demonstrate this concept experimentally by optimizing for maximum velocity in our synthetic model system, and achieve retraction velocities that exceed those in biological impulsive systems. This model system provides a foundation for future work connecting continuum performance to molecular architecture in impulsive systems.

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