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A model for the contraction of polymer gels created by the activity of molecular motors

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Abstract. We propose a mathematical model based on non-equilibrium thermodynamics to describe the mechanical behavior of an active polymer gel created by the inclusion of molecular motors in its solvent. When activated, these motors attach to the chains of the polymer network and shorten them creating a global contraction of the gel, which mimics the active behavior of a cytoskeleton. The power generated by these motors is obtained by ATP hydrolysis reaction, which transduces chemical energy into mechanical work. The model is based on the Flory and Rehner theory for polymer network swelling and considers species diffusion to describe the transient passive behavior of the gel. The active behavior is modeled defining a volumetric density of mechanical power generated by the motors, through ATP hydrolysis, which increases the strain energy of the polymer network. The latter is depicted by an increment of the crosslink density in the polymer network, reducing the entropy of the polymer network. The model is finally adapted to the problem of uniaxial contraction of a slab of gel and compared with experimental results, showing good agreement.

Speaker Biography. Mattia Bacca obtained a BS and MS in Civil Engineering and a PhD in Structural and Mechanical Engineering at the University of Trento in Italy, in 2013 (thesis supervisor: Davide Bigoni). He then joined the Department of Mechanical Engineering and Materials at the University of California, Santa Barbara as a Postdoctoral Fellow, working with Prof. Robert McMeeking. Then, he joined the Department of Mechanical Engineering at the University of British Columbia, Vancouver, in 2017, as a faculty member. His research involves the study and the application of fundamental aspects of the mechanics and physics of solids, with a focus on the relationship between macroscopic materials' properties and the materials' architecture at the micrometric and nanometric length scale. In particular, his recent interests involve bio-inspired adhesion, constitutive modeling of hydrogels, and cutting and penetration of soft materials.