Active Soft Matter: a Continuum Physics Perspective

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Active soft matter is the key constituent of living matter: its striking behavior is the capability of exploiting chemical energy to produce mechanical work, and thus, to move, change shape, and undergo many controlled transformations. As example, the mechanical behavior of cells can be controlled by a network of crosslinked filaments subjected to the action of energy-transducing molecular motors. This system is "out of thermodynamic equilibrium", and its functioning is based on the conversion of chemical power into mechanical power, together with the unavoidable dissipated power.

The study of this kind of active system has been absent from conventional physics; now, it is gaining an important role in both physics, as we need new experiments, and in mathematics, as we need new models. Above all, stands the will to understand the behavior of living matter.

Here we are interested in the dynamics of active gels, and we develop a model using the perspective of continuum physics: the activation of a polymer network is viewed within the context of a stress-diffusion theory, augmented with the theory of growth and remodeling. We start from the fundamental principles of virtual power and power dissipation, to put forth a theory which describes the state of an active gel with three fields: displacement, solvent content, and ground state. The mathematical model can describe some key features of the dynamics of contraction which is observed on active gels; the results of the model will be compared and contrasted with the observations of actual experiments.

Contents

- The statistical origin of free energy.
- The three pillars of Continuum physics: 1) state variables; 2) balance laws; 3) constitutive prescriptions.
- Swollen states
- Dynamics: time evolutive problems
- The contraction-swelling diagram
- Prototypical example: spherical active-swelling dynamics

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