Mechanical non-linearity in actin filament networks

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Animal cells are laden with actin filaments that form dynamic networks with precise localizations and biological functions. These networks, through the nucleation and polymerization of new filaments or through the translation of filaments by myosin motors, are responsible for most of the forces generated by the animal cell. Like numerous networks of biological fibers, actin networks can exhibit strongly non-linear mechanical properties, such as stress-stiffening. These properties are usually understood as a consequence of the entropic stretching of its filaments. This point of view however fails when applied to the weakly coordinated branched actin networks, such as those found at the leading edge of the migrating cell.

Through experiments - controlled compression of reconstituted actin networks between cylindrical magnetic colloids- and theory, we show that the elasticity of weakly coordinated actin networks crucially involves reversible contacts between their filaments [1]. This leads to a rapid increase of the apparent stiffness of the network as a function of applied stress, in direct resemblance to sheep's wool mechanics [2]. Moreover, these contacts can be controlled through filament entanglements during network growth to regulate the final properties of the network. Destabilizing the network through the addition of a biologically relevant actor of its dynamics showed that these networks can withstand very large deformations -down to a fraction of their original size - without appreciable structural failure.

These properties of non-linear elasticity are not confined to the networks at the leading edge of moving cells, as we found similar characteristics in the dense acto-myosin cortex below the membrane of animal cells. We measured the mechanical properties of these networks with a pair of magnetic colloids on either side of the cell boundary. We quantified a dynamic switch from an Hookean material to a wool-like material, that depends on cell type and cell state. These properties could be key to understanding how cells dynamically adapt their cytoskeleton to their environment.

Références

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2. C. M. van Wyk, *Journal of the Textile Institute Transactions*, **37**, T285 (1946).