The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5-9 June 2022, Oslo, Norway

Active self-organization in actin cytoskeleton

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Keywords: *Self-organization, Nematic Architecture, Active Gel, Finite Element Method.*

Actin networks exhibit a variety of architectures that contribute to different cellular functions. Notably, the actin cytoskeleton can adopt a nematic order, with aligned actin filaments of mixed-polarity associated with myosin-II and other actin-bundling proteins. These nematic actin bundles conform to a variety of contractile structures [1], including the cytokinetic ring [3], supra-cellular rings during wound healing [4] or stress fibers [2]. While biological literature emphasizes the morphological, dynamical, molecular and functional specificities of each of these families of bundles, observations across cell types also suggest that nematic strands emerge as a result of self-organization of the active actomyosin gel. To test this idea, we develop here an active gel model accounting for orientational order, in which order is promoted by flow and active power input and controls anisotropic active tensions. By performing linear stability and fully nonlinear simulations, we show how activity can drive the formation of a variety of out-of-equilibrium patterns reminiscent of those observed in in-vitro cellular phenomena such as in cell division, in assembly of sarcomeres and in different families of stress fibers.

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