

# Extensile to Contractile Transition in a 3D Active Microtubule Network

Bibi Najma, Anjali Sharma, Ben Rogers & Guillaume Duclos

Department of Physics Brandeis University, Waltham, MA, USA



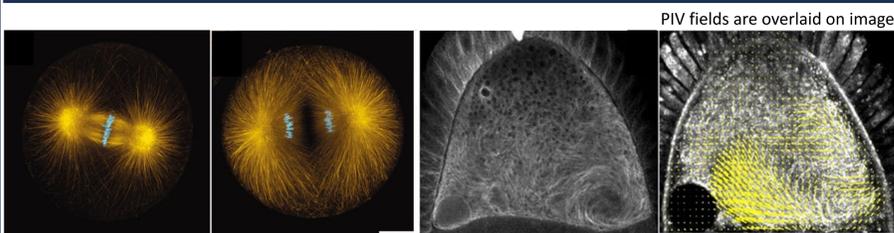
Brandeis



Brandeis  
bioinspired  
MRSEC



## The cell cytoskeleton is a remarkable adaptive material



Dynamic asters in mitotic spindles<sup>1</sup>.

Cytoplasmic streaming in a *Drosophila* oocyte<sup>2</sup>.

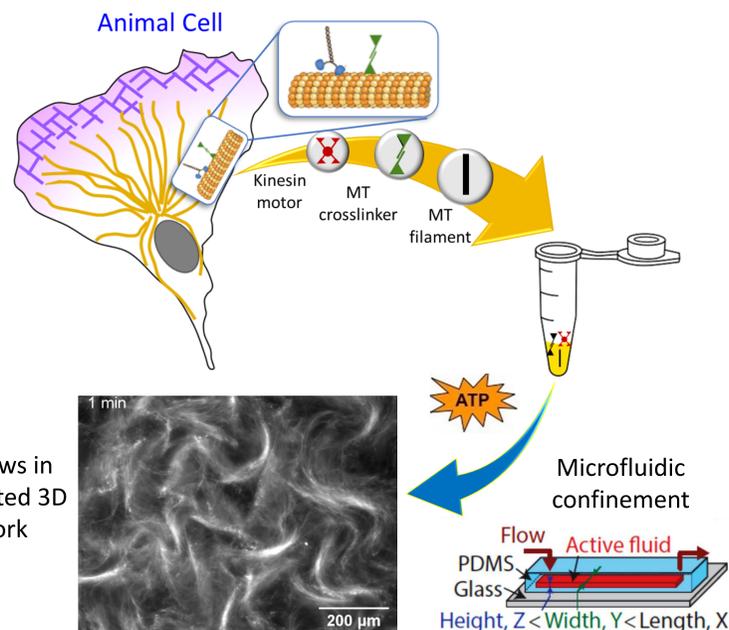
- Self-organization of molecular components of the cell cytoskeleton provides a variety of possible spatial structures to express cellular function

## References

- Mitchison, T., Wühr, M., Nguyen, P., Ishihara, K., Groen, A., & Field, C. M. (2012). 69(10), 738-750.
- Ganguly, S., Williams, L. S., Palacios, I. M., & Goldstein, R. E. (2012). *Proceedings of the National Academy of Sciences*, 109(38), 15109-15114.

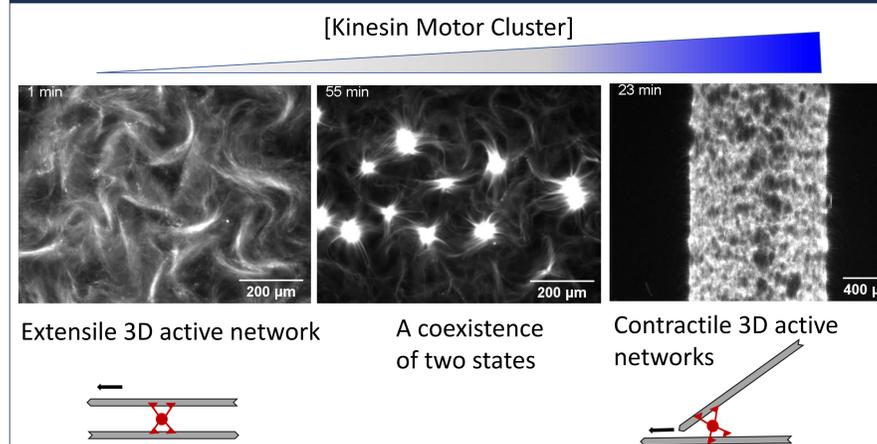
## Model reconstituted cytoskeleton system

**Research Goal:** How does the injection of energy at the particle scale modify the spatiotemporal organization of the reconstituted cytoskeleton networks?



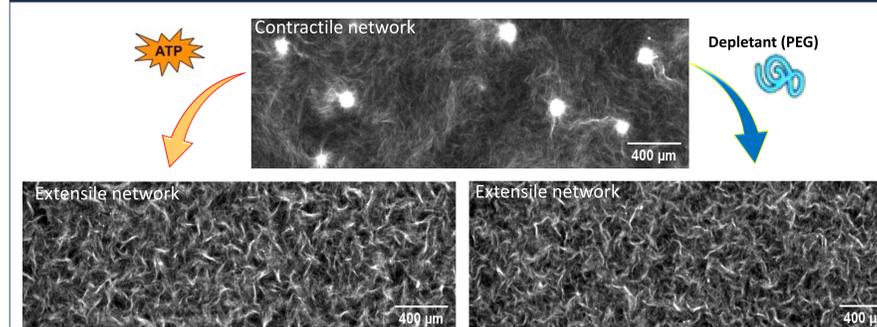
Extensile flows in a reconstituted 3D active network

## Increasing [motor] leads to a transition from an extensile to a contractile network

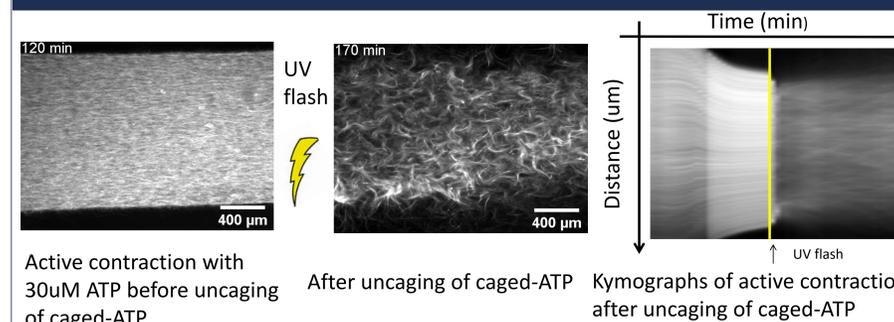


- Interaction geometry between MT & motor clusters is important. In an orientationally ordered state the MTs are crosslinked by motors in parallel or antiparallel fashion. The motors also tend to cluster MT plus ends in an orientationally disordered state

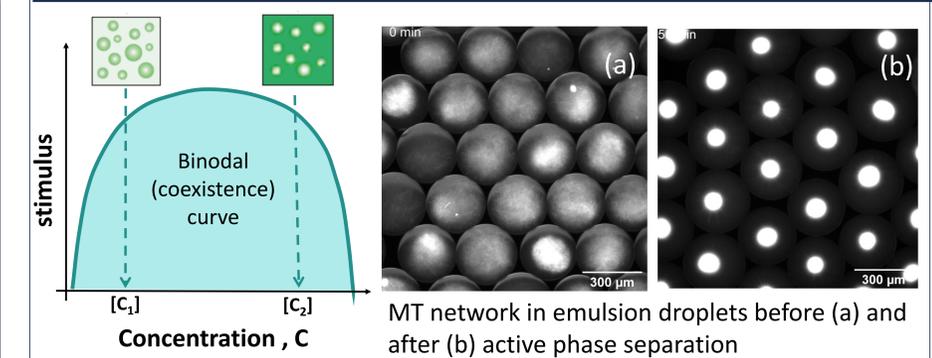
## Increasing [ATP] or [PEG] leads to a transition from a contractile to an extensile flow



## UV uncaging of caged-ATP leads to the active fluidization of a contractile MT network

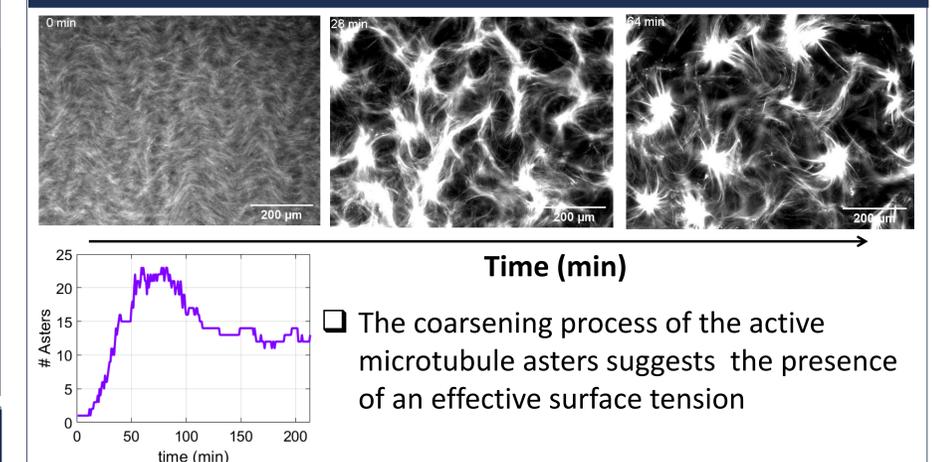


## Is active contraction in a 3D active MT network a condensation process?



- The contractile and extensile phases can coexist in 3D active MT network. At onset of contraction the active network phase separates into two distinct phases: a condensed contractile phase and a dilute extensile phase.
- A binodal distribution study could help us to explore & quantify the active phase separation process using emulsion droplets.

## Microtubule aster coarsening over time



- The coarsening process of the active microtubule asters suggests the presence of an effective surface tension

## Acknowledgments

We thank the director of the Brandeis Biomaterial Facility Shibani Dalal. We also acknowledge support from a NSF CAREER award DMR-2047119. We also acknowledge the use of the optical, microfluidics, and biomaterial facilities supported by NSF MRSEC DMR-2011846