Our question?

Active nematics are intrinsically unstable and unconfined active nematatics generate turbulent flows. In order to harness the chemomechanical abilities of these materials to do useful work, these dynamics need to be controlled. The Brandeis Active Matter IRG2 will address this grand challenge of design and control of active stress, to harness the autonomous dynamics of active materials.

To control the flow and suppress turbulence we developed a 2D active nematic system consisting of microtubule bundles driven by light activated kinesin motor clusters. Here, we investigate how the intensity of uniformly applied light affects active nematic properties. We use particle image velocimetry to calculate the nematic speed and the nematic director field to extract spatial and temporal nematic characteristics, such as the defect density. We find that at low light intensities, the intensity of light is proportional to the nematic speed and the defect density.

Our goal and experimental details

The goal is to control the microtubule-motor protein system dynamics using light to confine the system with light and tune the speed and the active nematic dynamics.

To control the light intensity in space and time, we used a Digital Light Processor (DLP). DLP is a projector composed of digital micro mirrors and a blue light LED ($\lambda = 460$ nm).

Results

Active nematic formed by optogenetic kinesin

Motor protein walks over the microtubule by hydrolyzing ATP and creates extensile system. 2D active nematatics have $+1/2$ and $-1/2$ topological defects which exhibit the active nematic dynamics.

Experiment

To maintain the active nematic structure for each intensity constant, after every cycle light is on to the max intensity.

Binding timescale

The duration to reach steady state velocity depends on the intensity.

Unbinding timescale

The time it takes for the system to stop is independent of the intensity.

Increasing blue light intensity leads to higher velocity

Nematic speed for different intensities

The amount of activation intensity tunes the nematic speed: higher light intensity increases the nematic speed.

References and acknowledgement

We acknowledge funding agencies:

Brandeis NSF MRSEC DMR-2011406

Zahra Zarei, John Berezney, Zvonimir Dogic, Seth Fraden

References