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# Active Polar Liquid Crystal Channel Flows: Analyzing the Roles of Nematic Strength and Activation Parameter

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## Introduction

Liquid crystals are a state of matter in between solids and liquids. They can be disc-like or rod-like. We study rod-like shape, suspensions of **active polar liquid crystalline polymers (APLC)** dissolved in a fluid. Our APLCs are "active," meaning they have internal movement. We model this internal movement as the activation parameter. The nematic concentration describes their strength the strength of the potential for nematic order, or their ability to self-align. When these two parameters are varied, we see complex phenomena such as spontaneous flows, pattern formations and defects. View a short video on liquid crystals here.

## Methodology

We use to the Kinetic Equations to model how the polymers move through a fluid. The Smoluchowski Equation describes the interactions of the individual molecule. Navier-Stokes Equations describe the velocity-pressure relationship of the molecule in the fluid. Dirichlet and Neumann boundary conditions are employed. Initial Conditions contain a perturbed isotropic state. We use the **Finite Difference Method** for to solve system of Partial Differential Equations. Our model is one-dimensional, thus a "channel" of liquid crystals. The simulations presented here have Dirichlet BCs and parallel anchoring of the molecule along channel walls.

**Fig. 1** Nematic Director (N) vs. Activation Parameter (PCT > 0)

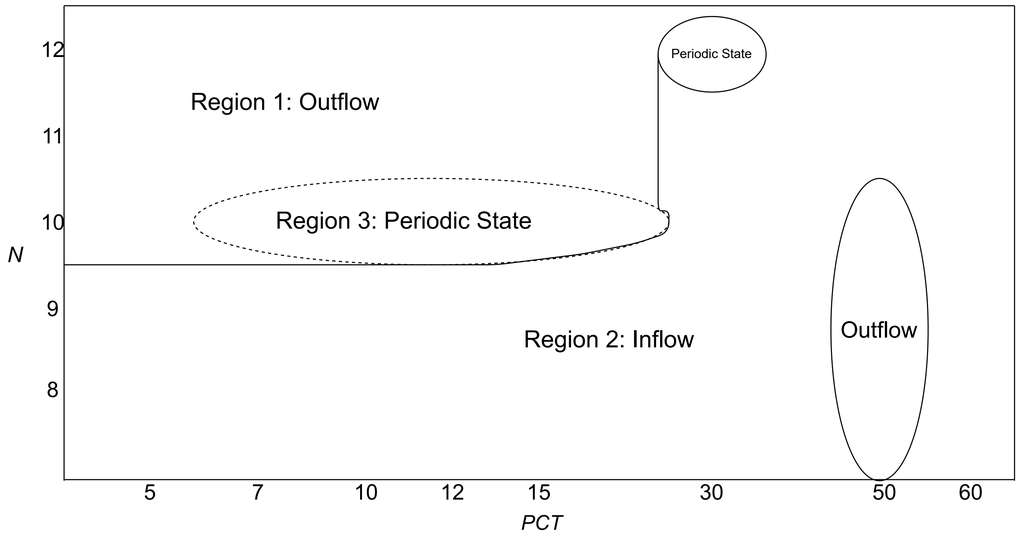



**Fig. 2** Region 1, Steady State: "Outflow"

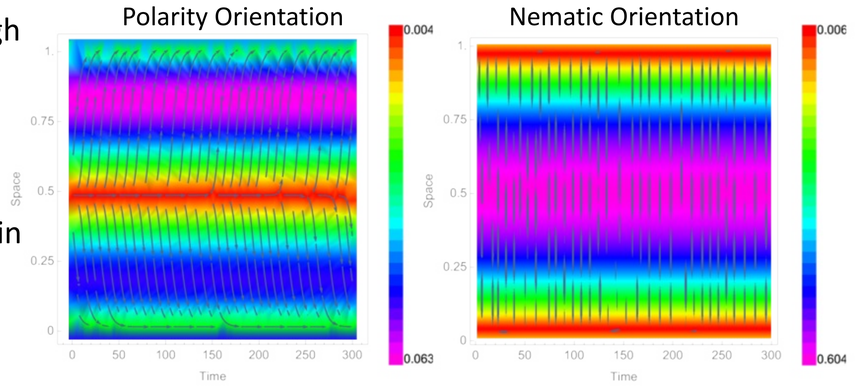



**Fig. 3** Region 2, Steady State: "Inflow"

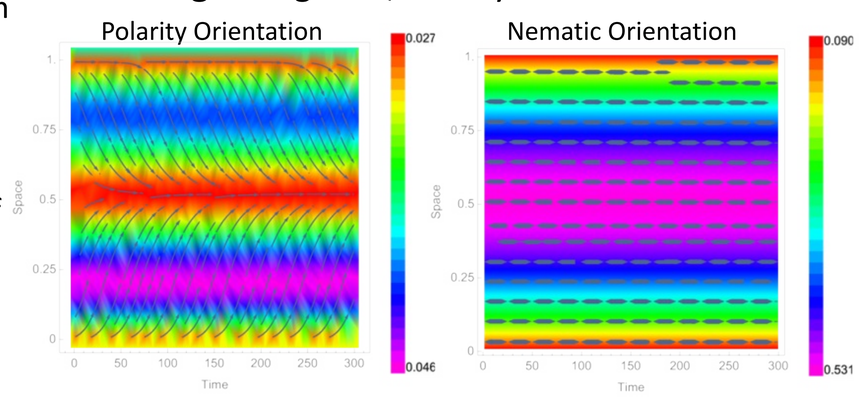
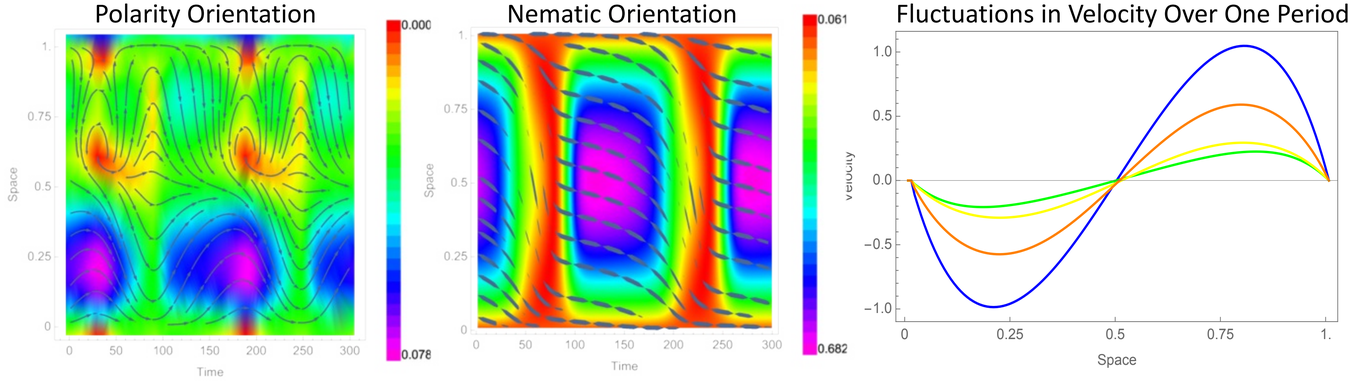



**Fig. 4** Region 3, Periodic State




## Results

Fig.1 shows a phase diagram of the different pairings of the nematic direction (N) and activation parameter. The three regions yield different spontaneous flows. Region 1 and Region 2 are both reach steady state convergence and two distinct, spatially-symmetric polymer regions. Region 1 polymers point towards the channel walls, while Region 2 polymers point toward the center of the channel. Region 3 shows the collection of simulations that have a periodic state, or a fluctuation that continuously occurs over time.

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