A polarization mechanism for bent core fiber stability

Presented by Chris Bailey

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Co-workers,

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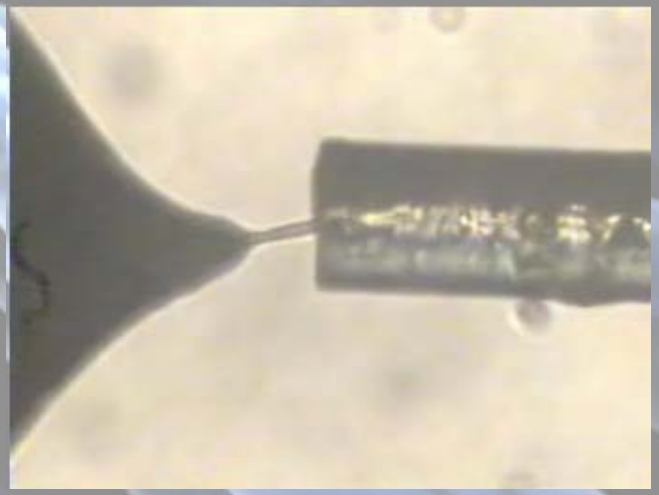
Experimental Observations

- Filaments first reported in 1999.
- B_2 (SmCP) and B_7 phases formed very stable fibers.
- Fibers are most stable in the B_7 phase.

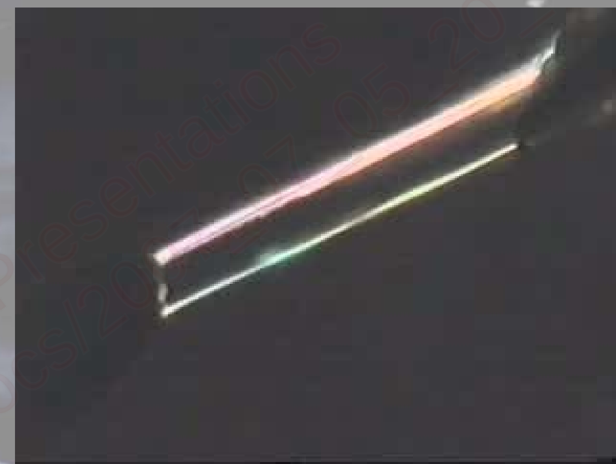
Isotropic phase

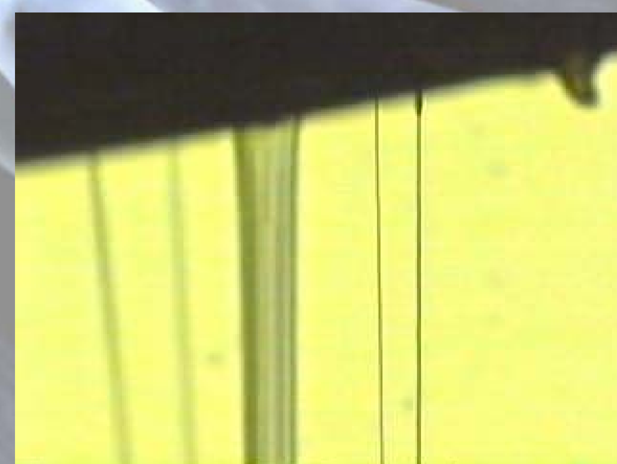
B_7 phase



Experimental Observations

- **Single fiber diameter range (2-6μm)**
- **Slenderness ratios (L/D) can exceed 4000**
- **Have viscoelastic properties**
- **Have interesting electric field interactions**





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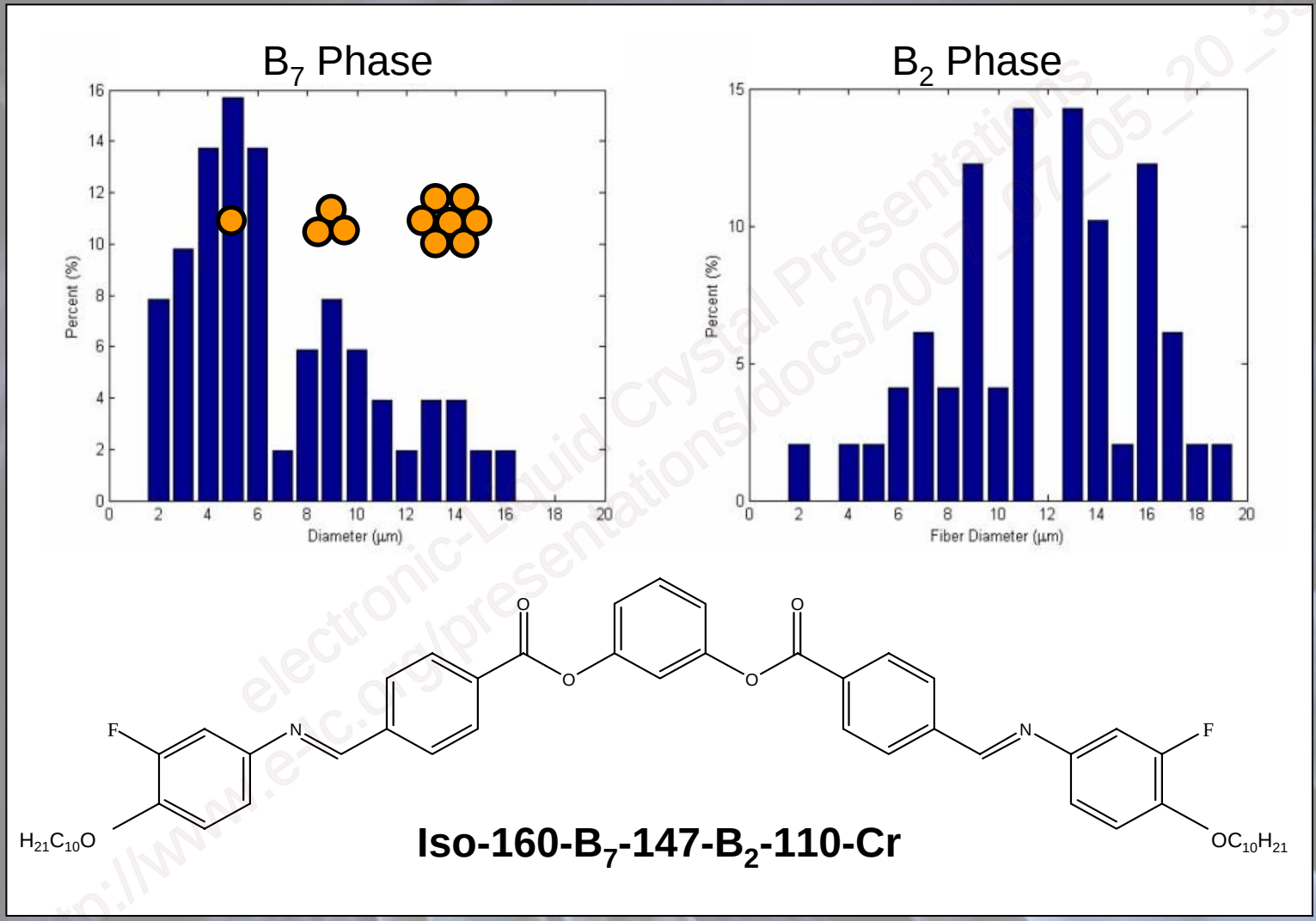
Experimental Observations



Iso-160-B_7-147-B_2-110-Cr

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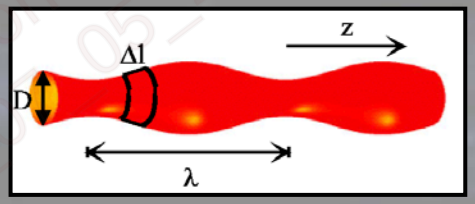
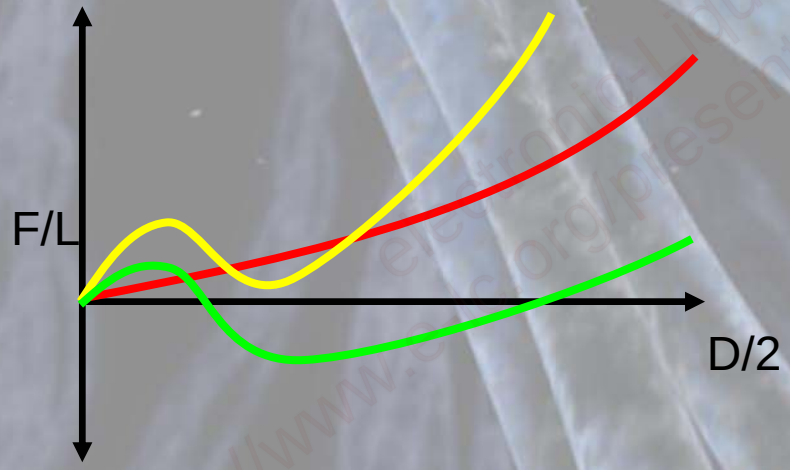
Stability models

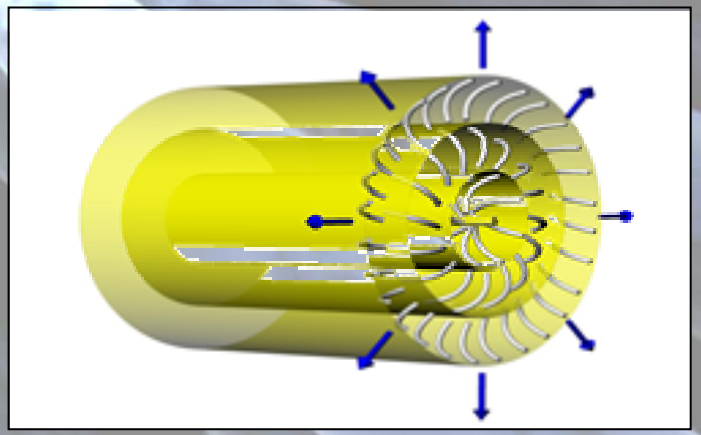
- Longitudinal fluctuations
  - Modified Plateau-Rayleigh instability

$$\frac{L}{D} < \frac{\pi}{\sqrt{1-\frac{BD}{\sigma}}} \quad \text{always true if} \quad D \geq \frac{\sigma}{B} \approx 0.3\mu m$$



- Radial fluctuations





D.H. Van Winkle, N.A. Clark, *Phys. Rev. Lett.*, 48, 1407 (1982)

A. Jakli, A. Saupe, "One and Two Dimensional Fluids", Taylor & Francis, (2006)

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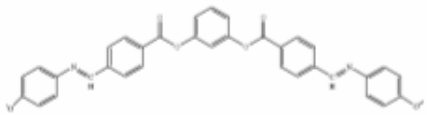
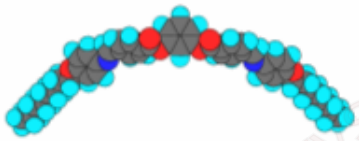
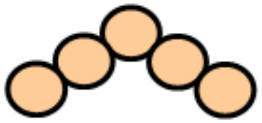
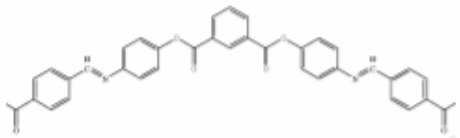
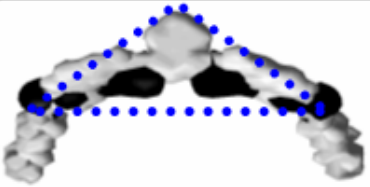
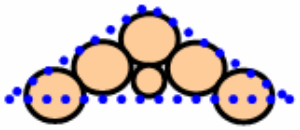
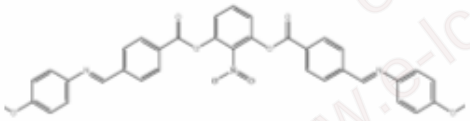
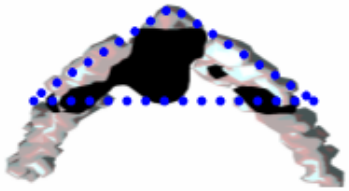
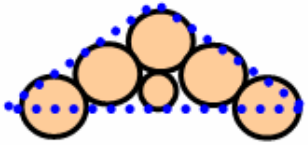
Stability via close packing

Phase Sequence and Chemical Structures	Steric Structures	Electrostatic Structures	Model Structures
a.) Cr 140 B_2 170 Iso 			
b.) Cr 174 B_2 180 B_7' 184 Iso 			
c.) Cr 116 $B_{7\text{-}NSw}$ 177 Iso 			

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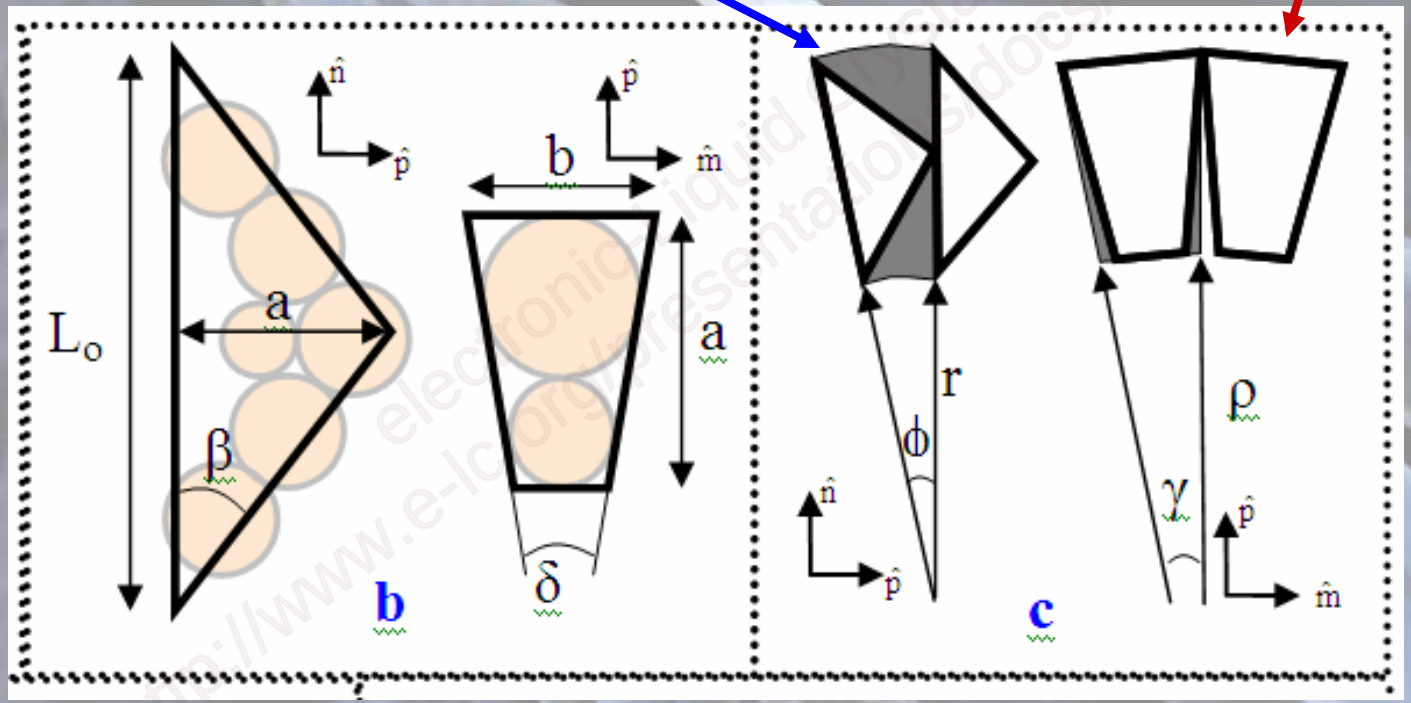
Frustrated Packing Results

$$K_b = 6.6 \times 10^{-11} N$$

$$C = 0.034 \, {}^{N}/_{m}$$

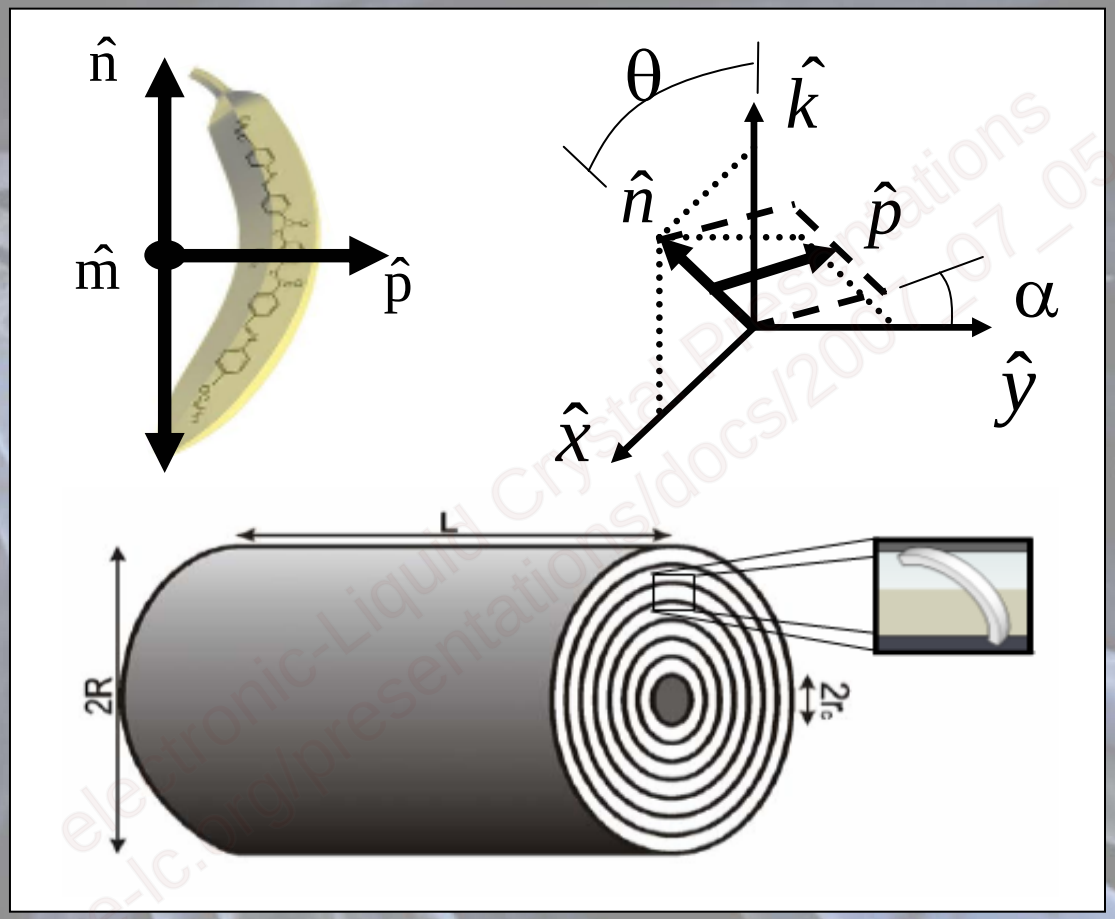
$$-\tfrac{1}{2} K_b \left(\hat{c} \times \left(\vec{\nabla}_\perp \times \hat{p} \right) \right)^2$$

$$-C\left(\vec{\nabla} \cdot \hat{p} \right)$$



C. Bailey and A. Jakli, *Phys. Rev. Lett.*, In review process (2007)

Model Geometry



$$\Phi(R,\alpha) = \frac{F(R,\alpha)}{2\pi L} = \int_{r_c}^{R} f_B(r,\alpha) r\, dr + RS(\alpha).$$

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Fiber Stability Model

- We considered the following contributions

Director $f_N(r) = \frac{1}{2} K \left(\left(\vec{\nabla} \cdot \hat{n} \right)^2 + \left(\vec{\nabla} \times \hat{n} \right)^2 \right)$

Dipolar $f_D(r, \alpha) = -C \left(\vec{\nabla} \cdot \hat{p} \right)$

Electric $f_E = \frac{1}{2} \vec{D}_i \cdot \vec{E}_i - \vec{P} \cdot \vec{E}_i$

Compression $f_C = \frac{1}{2} B_{biax} \left(\sin^2 \alpha - \sin^2 \alpha_o \right)^2$

Surface $S = \sigma_o$

C. Bailey, E.C. Gartland Jr., and A. Jakli, *Phys. Rev. E*, 75, *031701* (2007)

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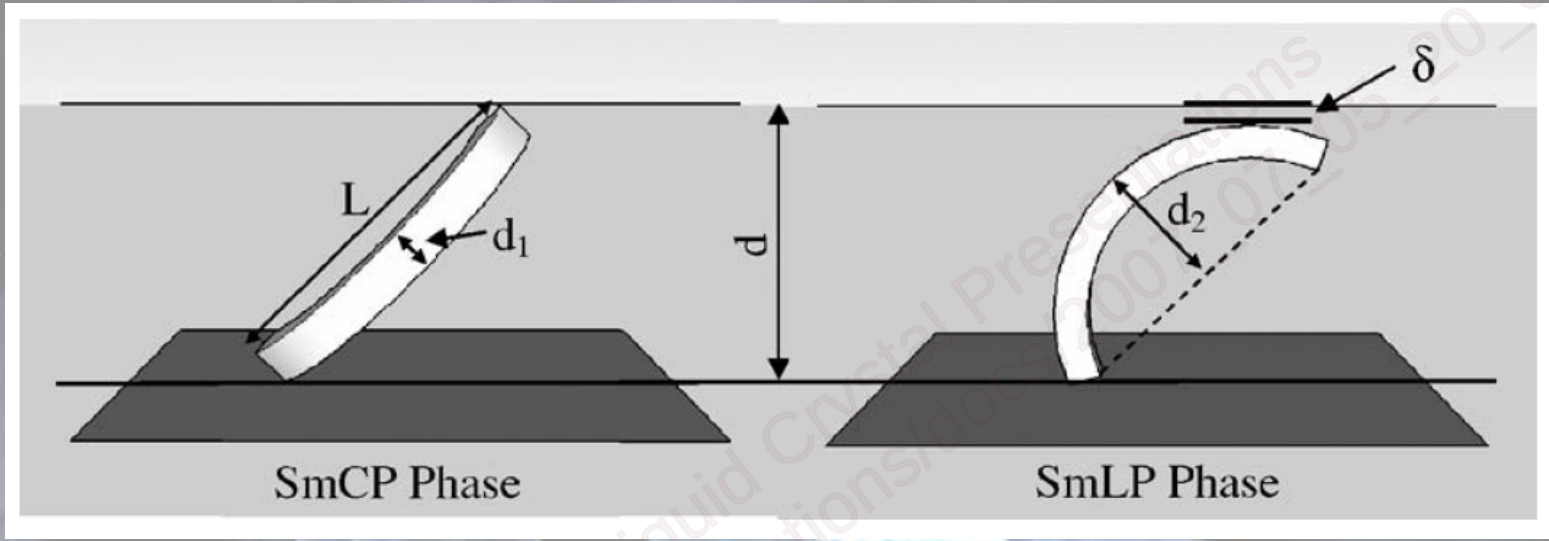
Biaxial Layer Compressions



Biaxial layer compression plays a role in holding the layer chirality to a set value.

$$f'_C(\alpha) = \frac{1}{2} B_c (\chi^2 - \chi_0^2)^2$$

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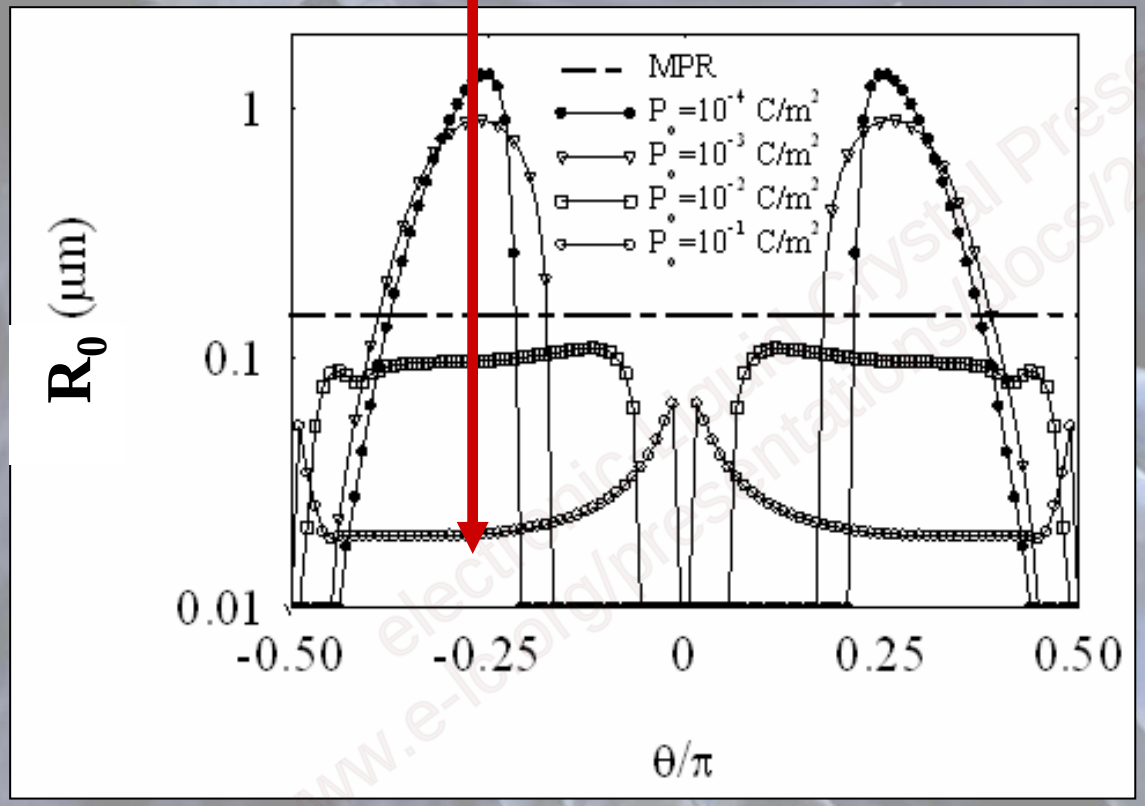
Simulation Summary

Increasing Polarization



SmAP materials cannot form fibers.

Polarizations approx. larger than 1000nC/cm^2 cannot form stable fibers.

C. Bailey, E.C. Gartland Jr., and A. Jakli, *Phys. Rev. E*, 75, *031701* (2007)

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Analytic Results

- Analytic Solution (For R>>L)

$$R_0 = \frac{|C| - \sigma_0}{\frac{3}{2}\frac{(P_o \sin\theta)^2}{\varepsilon_o \varepsilon_{ave}} + \frac{1}{2} B_{biax}}$$

$$R_0 \approx 1.5 - 2\mu m$$

C. Bailey, E.C. Gartland Jr., and A. Jakli, *Phys. Rev. E*, 75, *031701* (2007)

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Summary

- B_7 fiber stability can be stabilized with a SmCG type model.
- Electric self interactions and polarization splay become dominate interactions.
- Behavior can be understood in the construct of an inclusion which frustrates close packing.

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