Giant flexoelectricity of bent-core nematic liquid crystals

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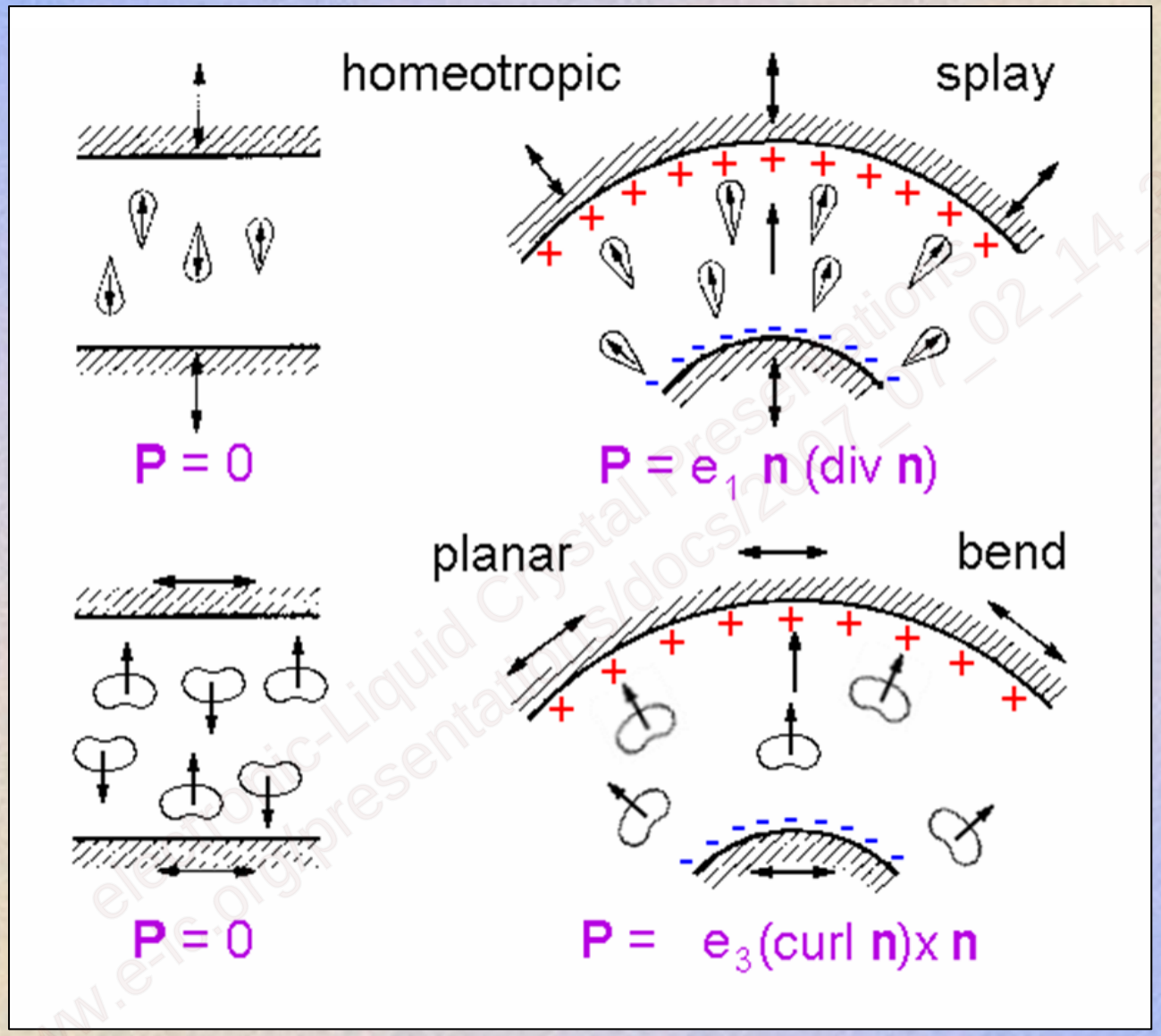
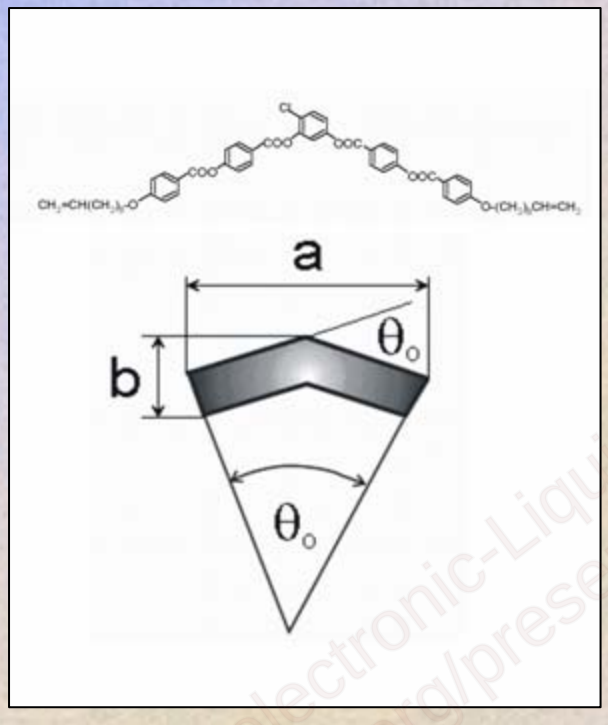


$$\vec{P}_f = e_1\vec{n}\left(div\,\vec{n}\right) + e_3\left(curl\,\vec{n}\right)\times\vec{n}$$



Helfrich[1] and Derzhanski and Petrov[2] Model

$$e_3 = \frac{\mu_\perp K_{33}}{2k_B T}\theta_o \left(\frac{b}{a}\right)^{2/3} N^{1/3}$$

For bent-core molecules θ_0~60°, expect e_3 nC/m order of magnitude.

For rod shaped molecules θ_0 <1°, e_1 and e_3 typically 10^{-2} - 10^{-3} nC/m

[1]W. Helfrich, *Phys. Lett.*, ***35A*, 393 (1971);** *Z. Naturforsch,* **26a, 833 (1971)**
[2] A. Derzhanski, A.G. Petrov, *Phys. Lett.*, **36A, 483 (1971)**

Measuring the Coefficients Optically

- Requires previous knowledge of many material parameters elastic,
  dielectric constants, birefringence, anchoring energies etc.

- Same data yields different e_1 and e_3 depending on technique.

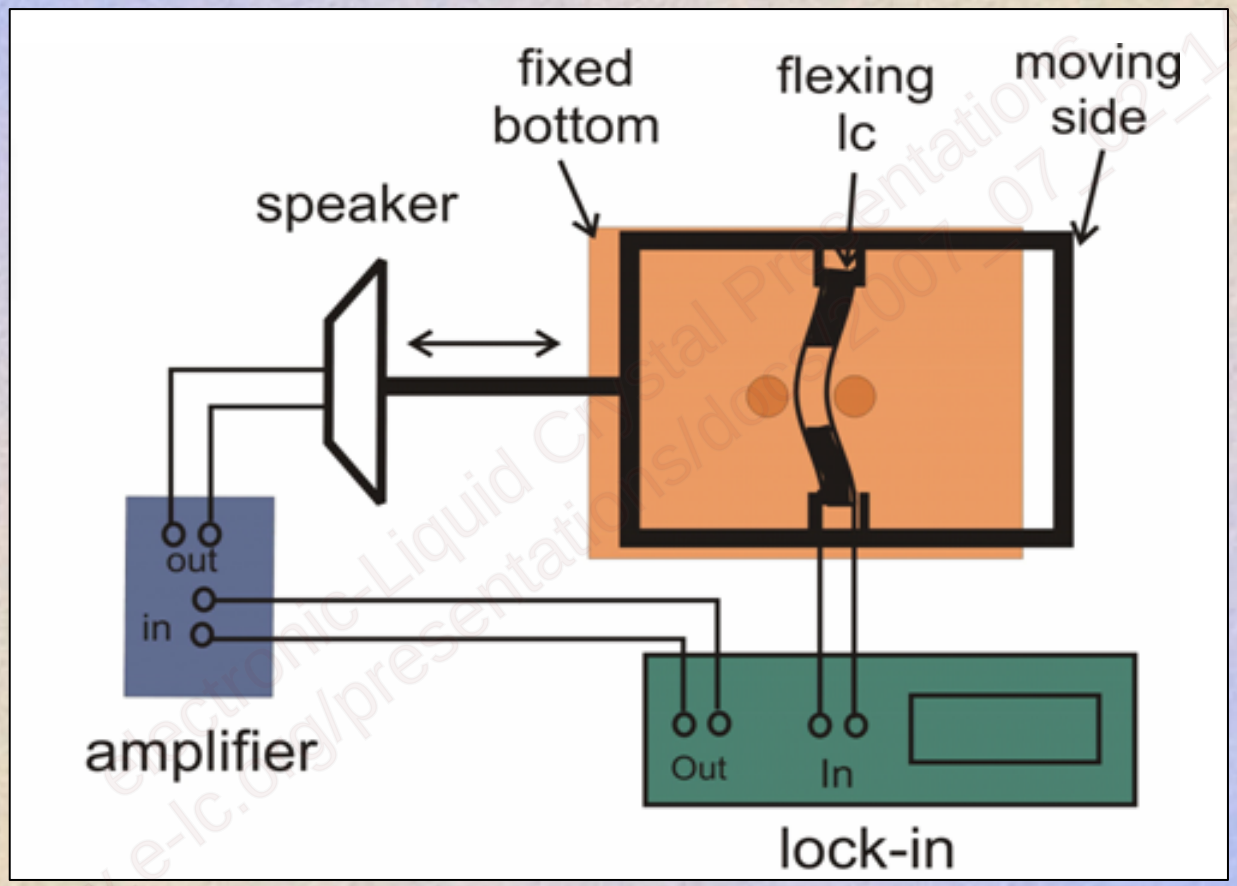
- Coefficients e_1 and e_3 can not be measured independently.

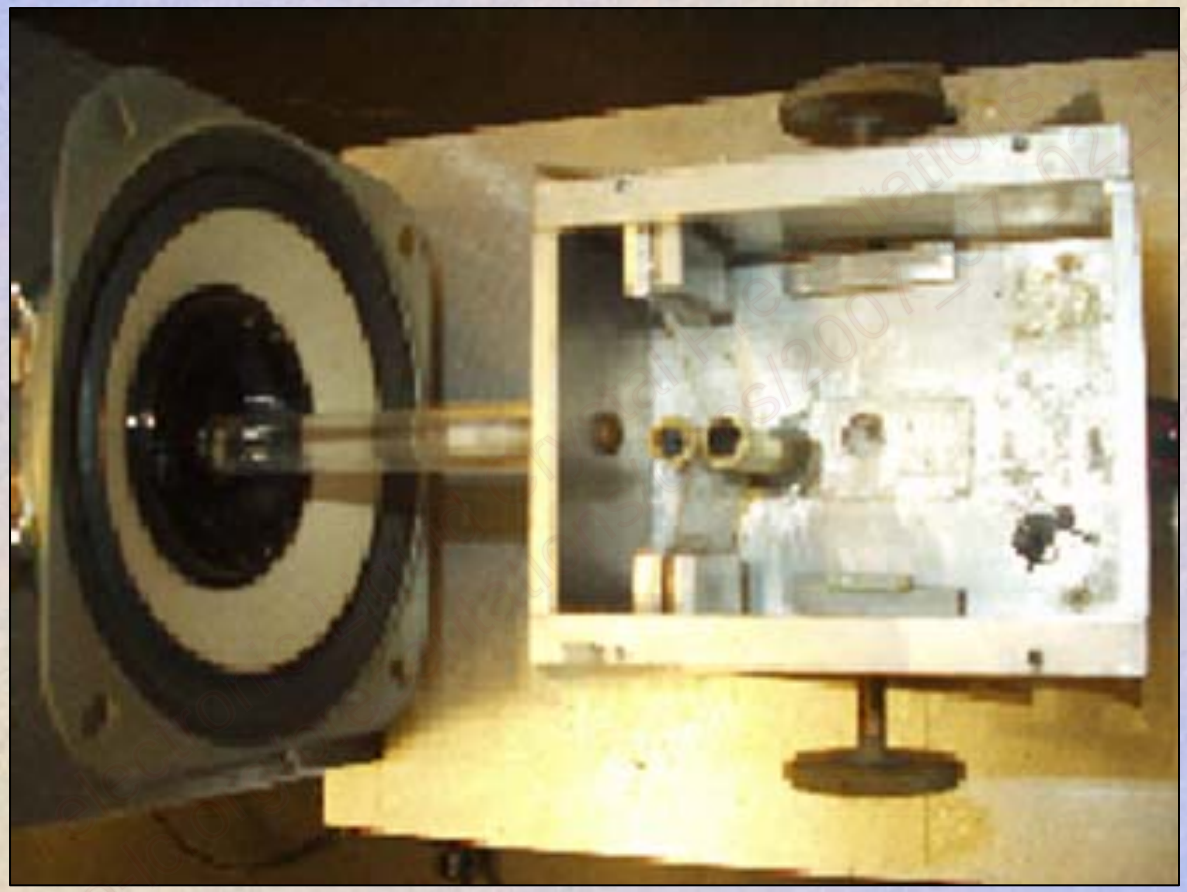
- Bent-core molecules will align planar if it has a large dipole.

Direct Flexing Technique

- Bent-core molecules can be measured.
- Coefficient e_3 is measured independently
- No previous knowledge of material parameters is required.

Experimental Setup





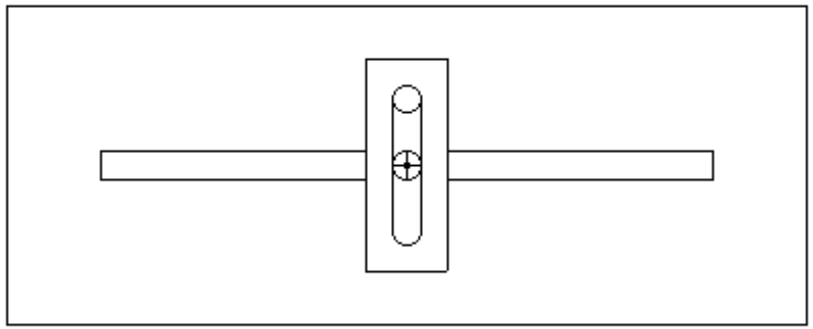
Scotch Yoke Mechanism

Converts Rotation to SHM

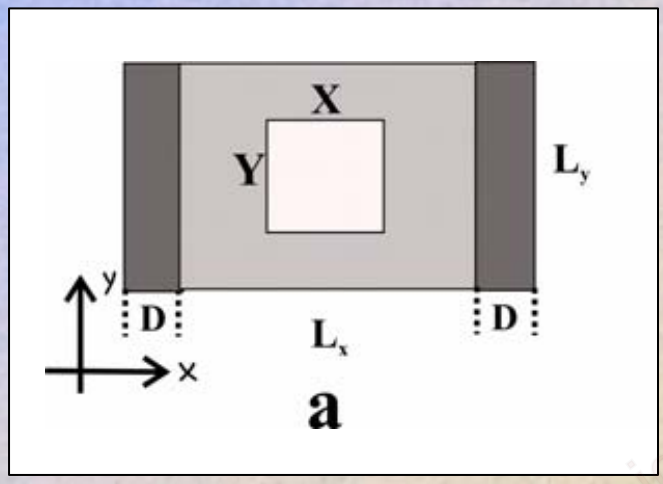
Uses a DC Motor that spins at a High Frequency

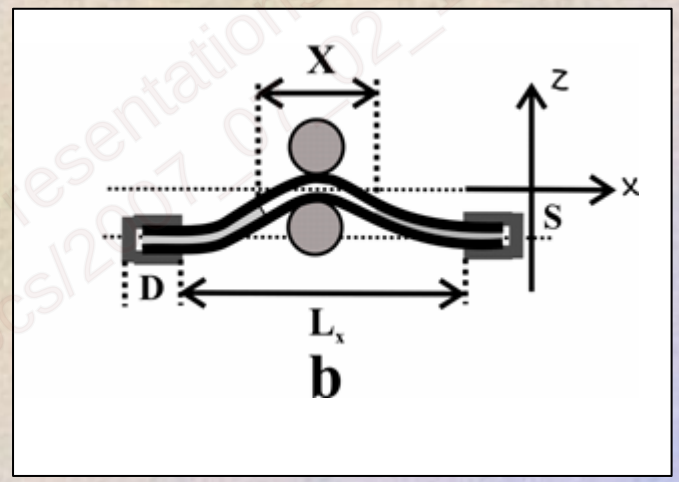
Can Vary Frequency while Holding Amplitude Constant

Helps Minimize Induced Currents



Determining e_3





$$|e_3| = \frac{\sqrt{2} I_{rms}}{6 X \omega S_0} \frac{L_x^2}{Y}$$

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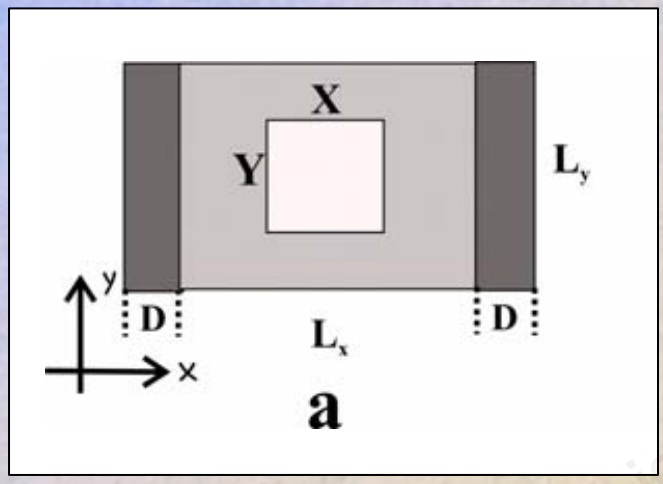
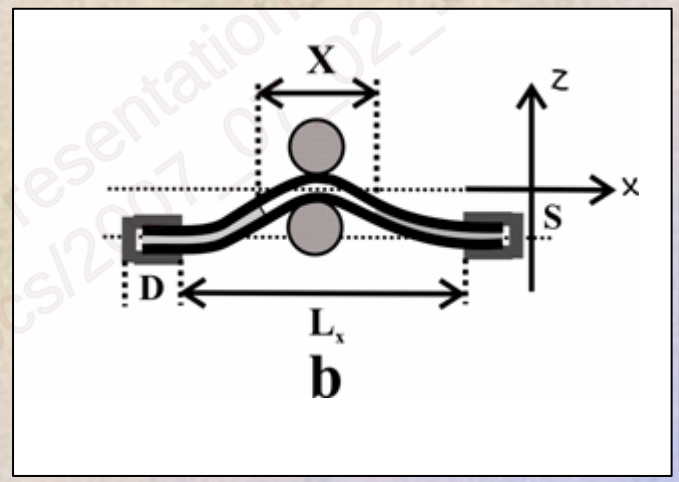
Determining e_3





$$\sqrt{2}I_{rms} = |e_3| XY\omega\left(\frac{6S_0}{L_x^2}\right)$$

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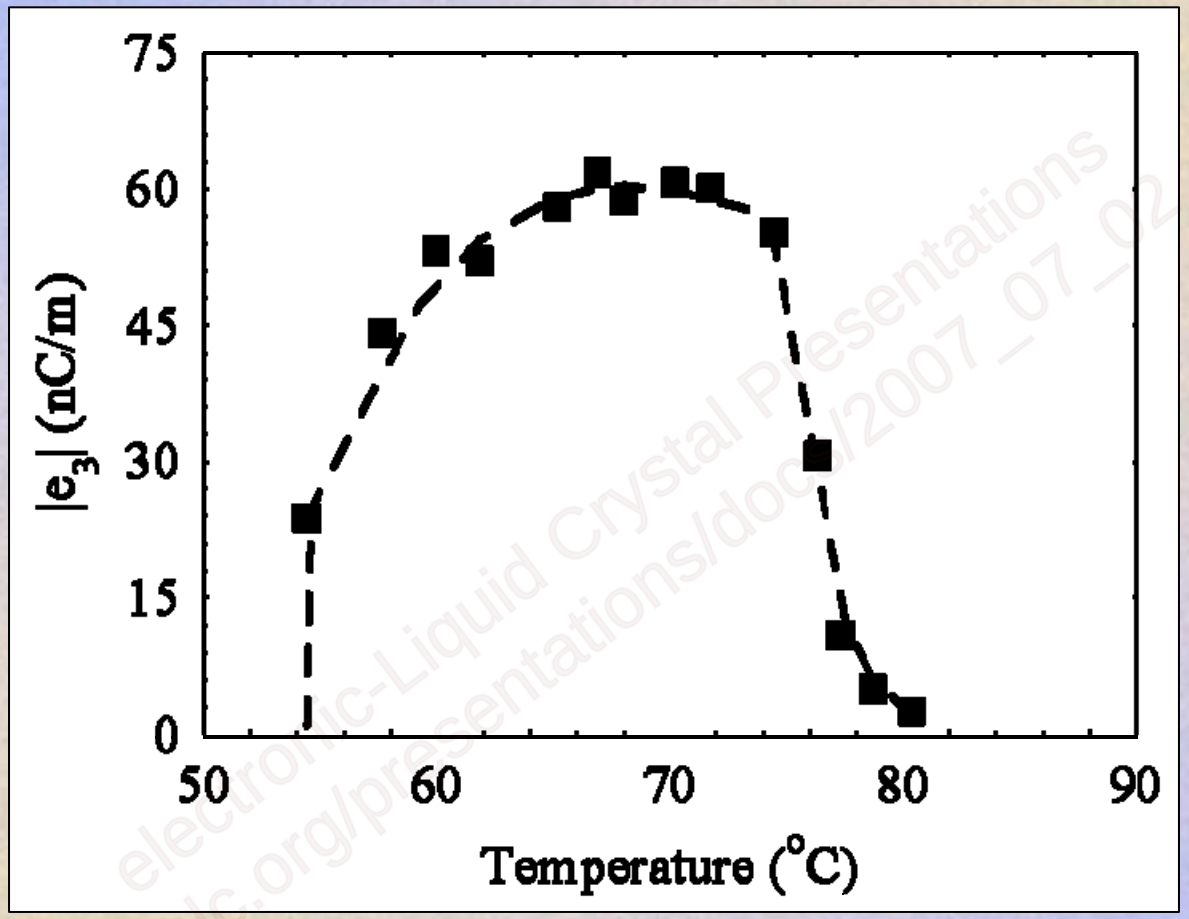
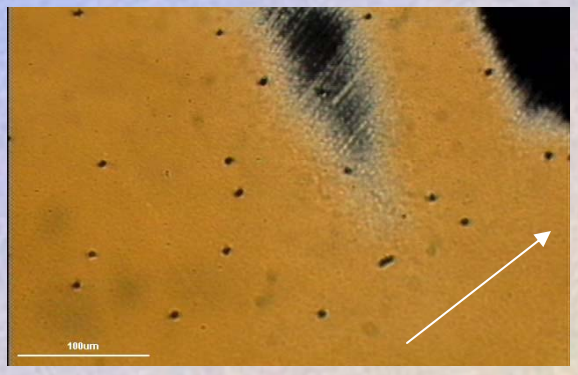
Results Obtained by the Direct Flexing Method with the Audio Speaker as the Driver



The temperature dependence of |e3| of a well aligned cell measured at 5Hz in 15mm x 15 mm active area plastic cells. Material is ClPbis10BB

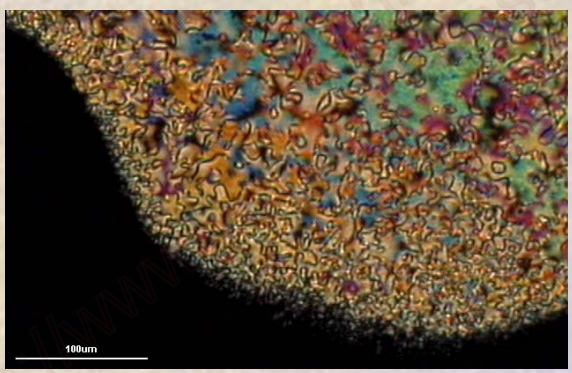
*4-chloro-1,3-phenylene bis 4-[4'-(9-decenyloxy) benzoyloxy] benzoate

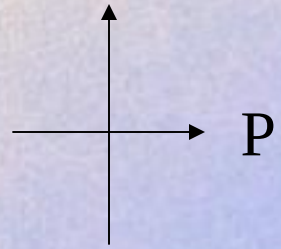
Well Aligned Cell



White Arrow Denotes Rubbing Direction

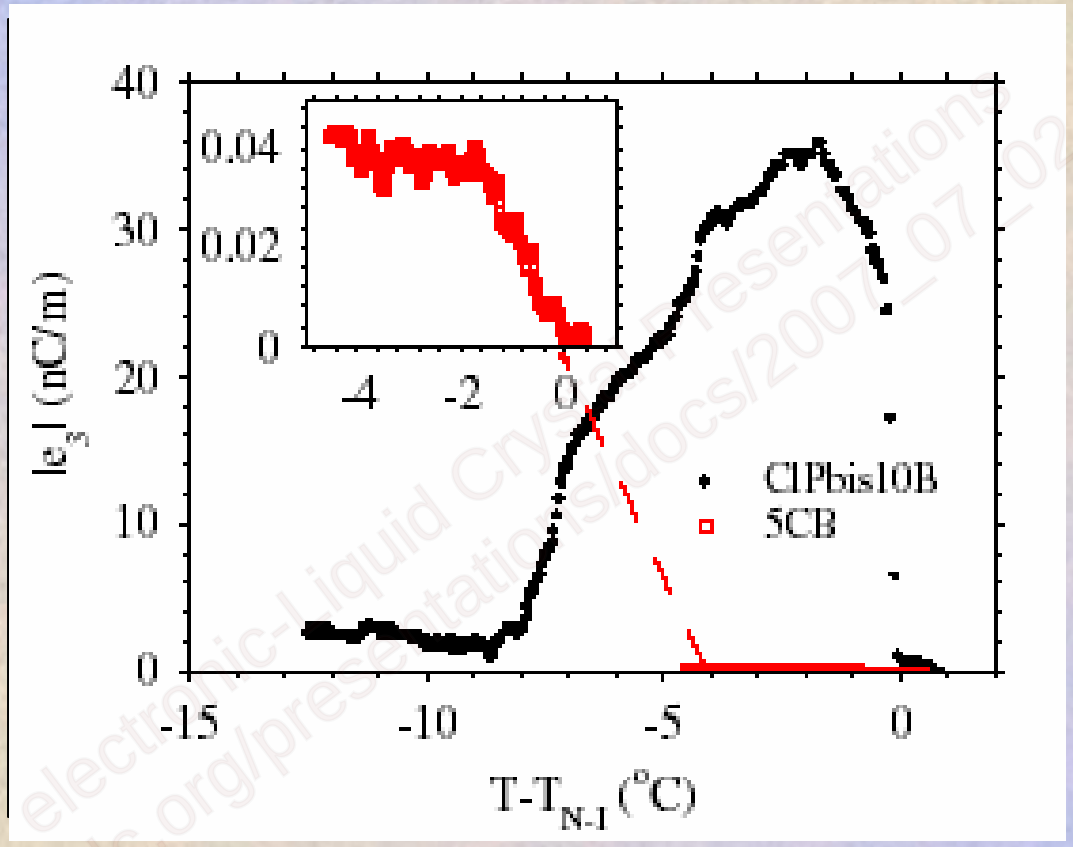
Poorly Aligned Cell





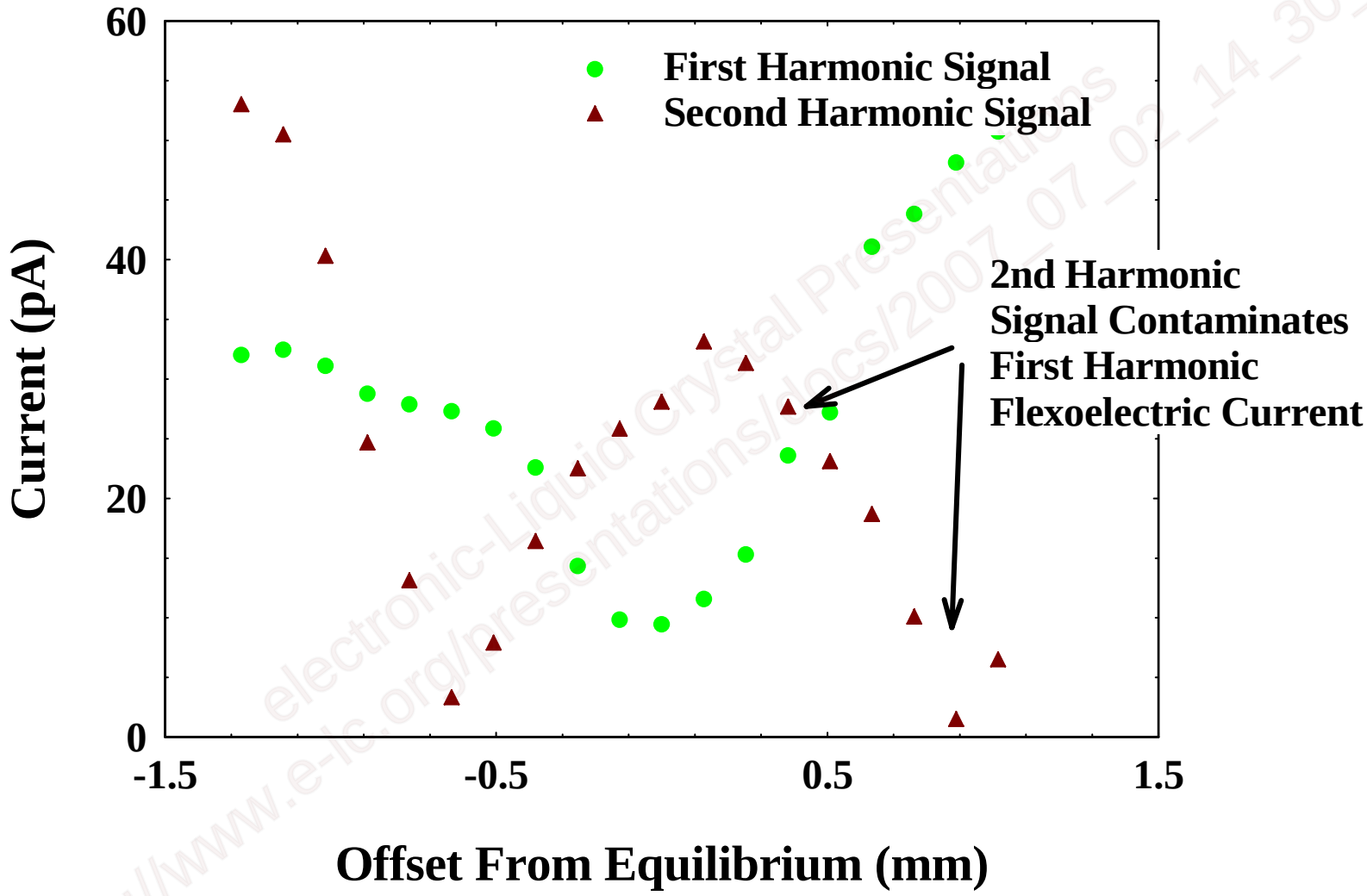
Measurements in Brass Cell with No Alignment Layer

For ClPbis10BB and 5CB



Variation of the flexoelectric coefficient on a relative temperature scale T-TN-I for the bent-core liquid crystal ClPbis10BB as well as for the calamitic liquid crystal 5CB measured in cells of A=1cm2 active areas. The inset shows part of the figure (|e3| of 5CB) at a magnified scale.

Capacitance Bleeding



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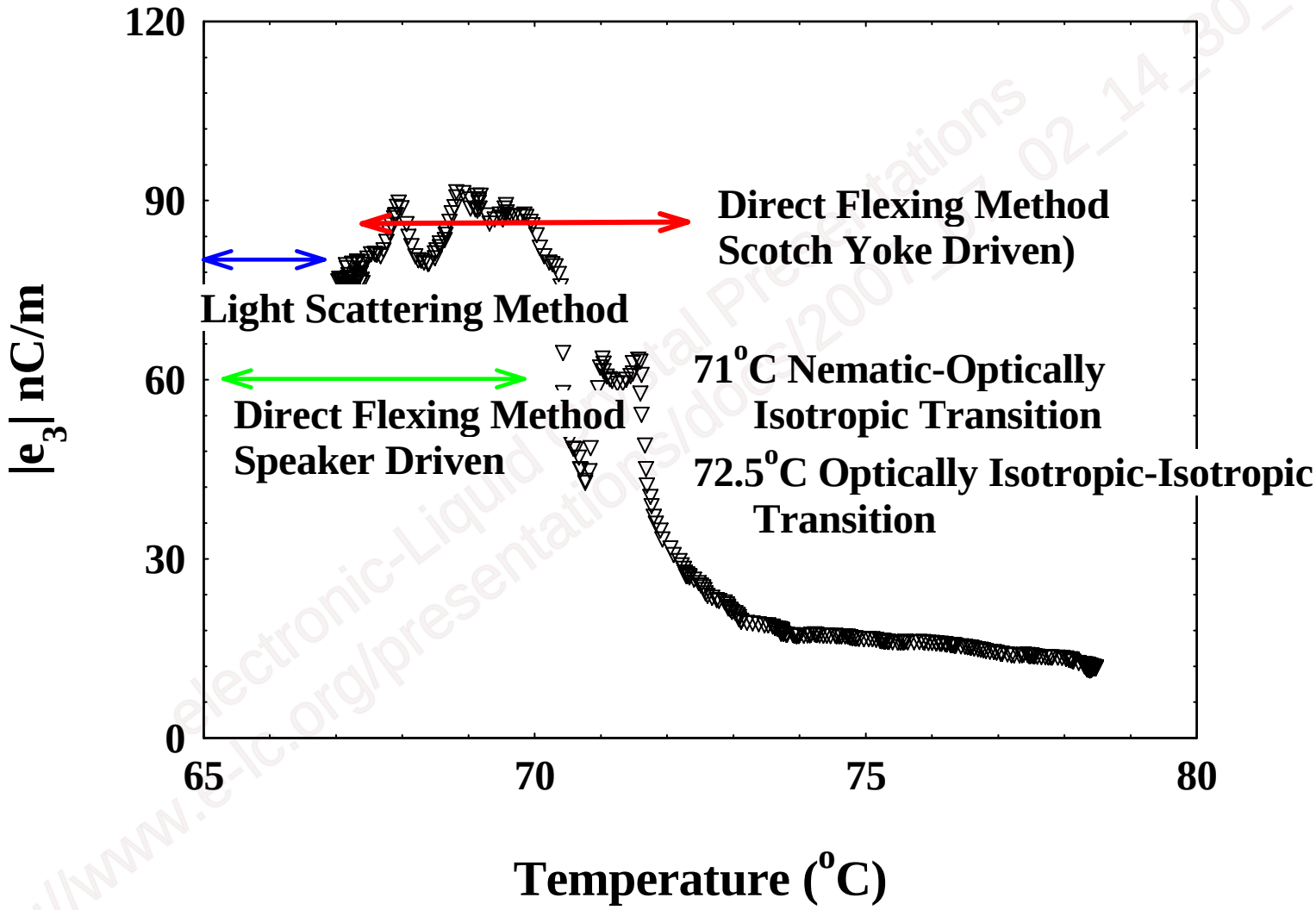
ClPbis10BB
120
90
60
30
0
65
70
75
80
|e3| nC/m
Temperature (°C)
Direct Flexing Method
Scotch Yoke Driven)
Light Scattering Method
Direct Flexing Method
Speaker Driven
71°C Nematic-Optically
Isotropic Transition
72.5°C Optically Isotropic-Isotropic
Transition

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- Julie Kim
- Madhabi Majumdar