Catalytic Activity in Vesicles

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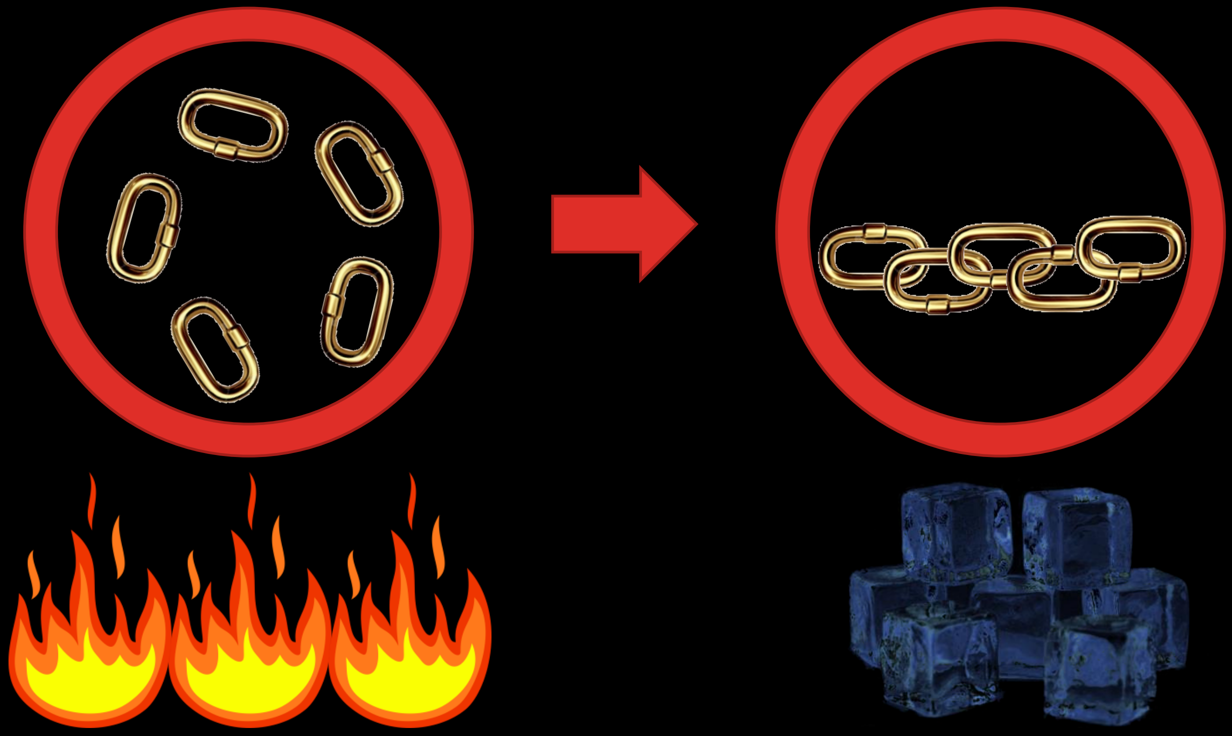
Dynamic Light Scattering
Sol to Gel States

Gelatin Solution

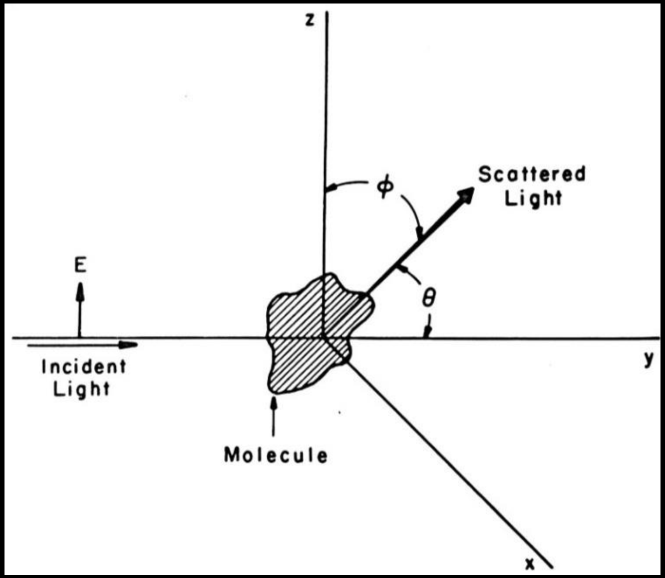


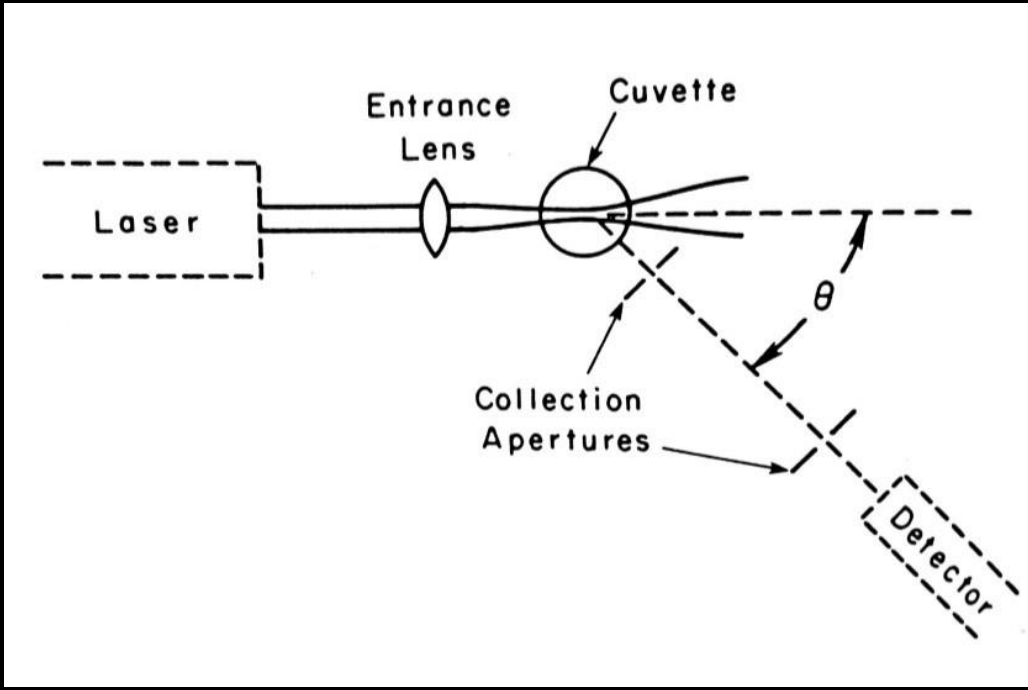
40° C

~20° C

DLS & Photon Correlation Spectroscopy (PCS)

- Solid State Laser Requirements
  - Low Noise
  - Vertical Polarization

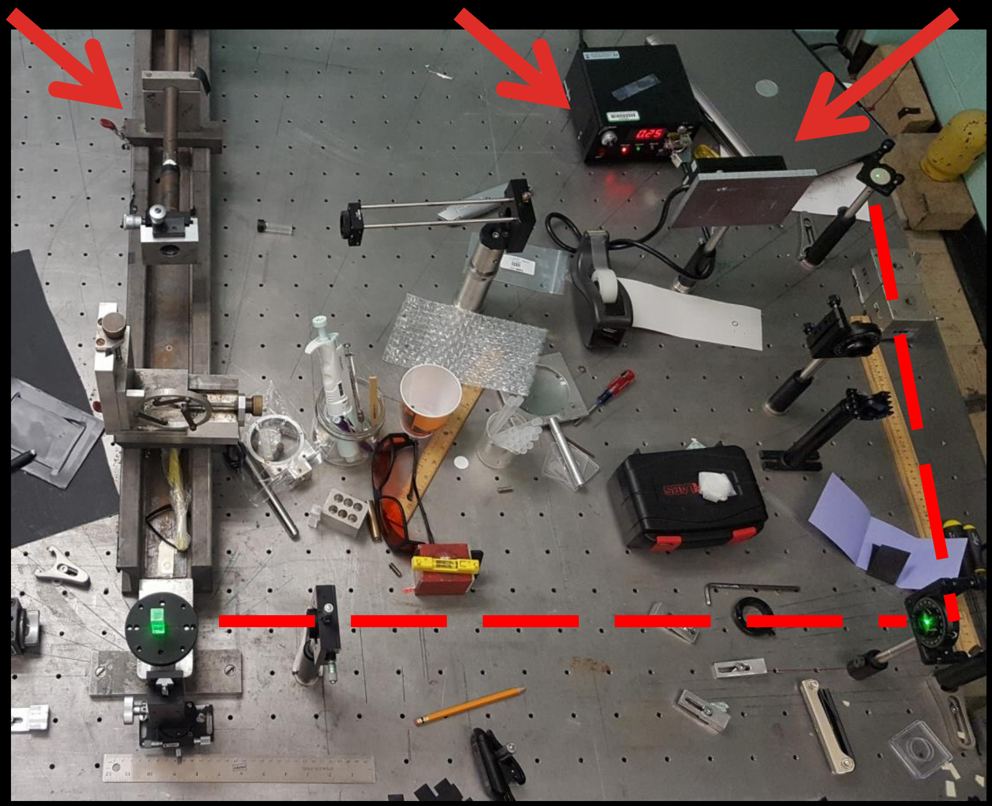




Dahneke, Barton E. (1983), *Measurement of Suspended Particles by Quasi-elastic Light Scattering* **34,50**

DLS & PCS

PMT & Detector   Laser Intensity Control   Solid State Laser



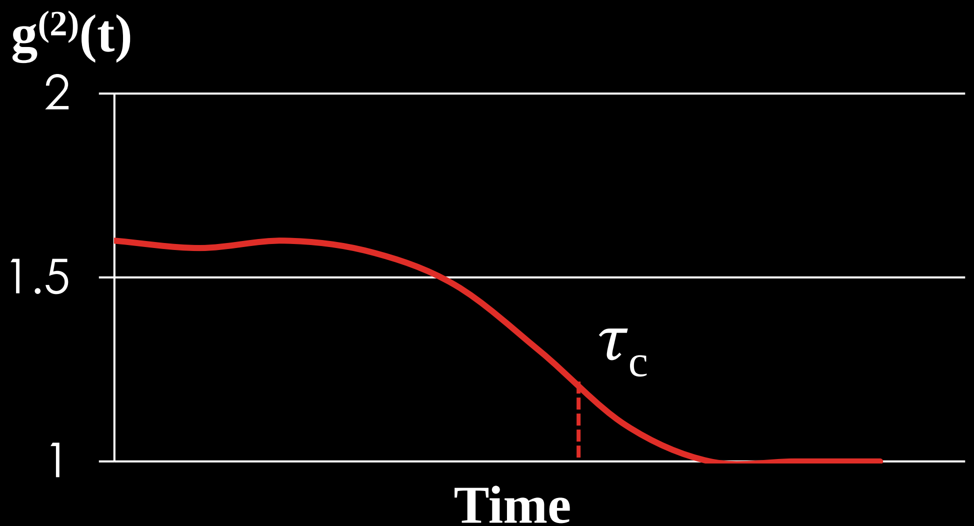
DLS & PCS

Correction Function for Intensity

$g^{(2)}(t) \equiv \langle I(t)I(0)\rangle \equiv$ Intensity Correlation Function

For Gaussian Scattered Light

$g^{(2)}(t) \equiv 1 + |\langle E(t)E(0)\rangle|^2 = 1 + |g^{(1)}(t)|^2$ Field Correlation Function



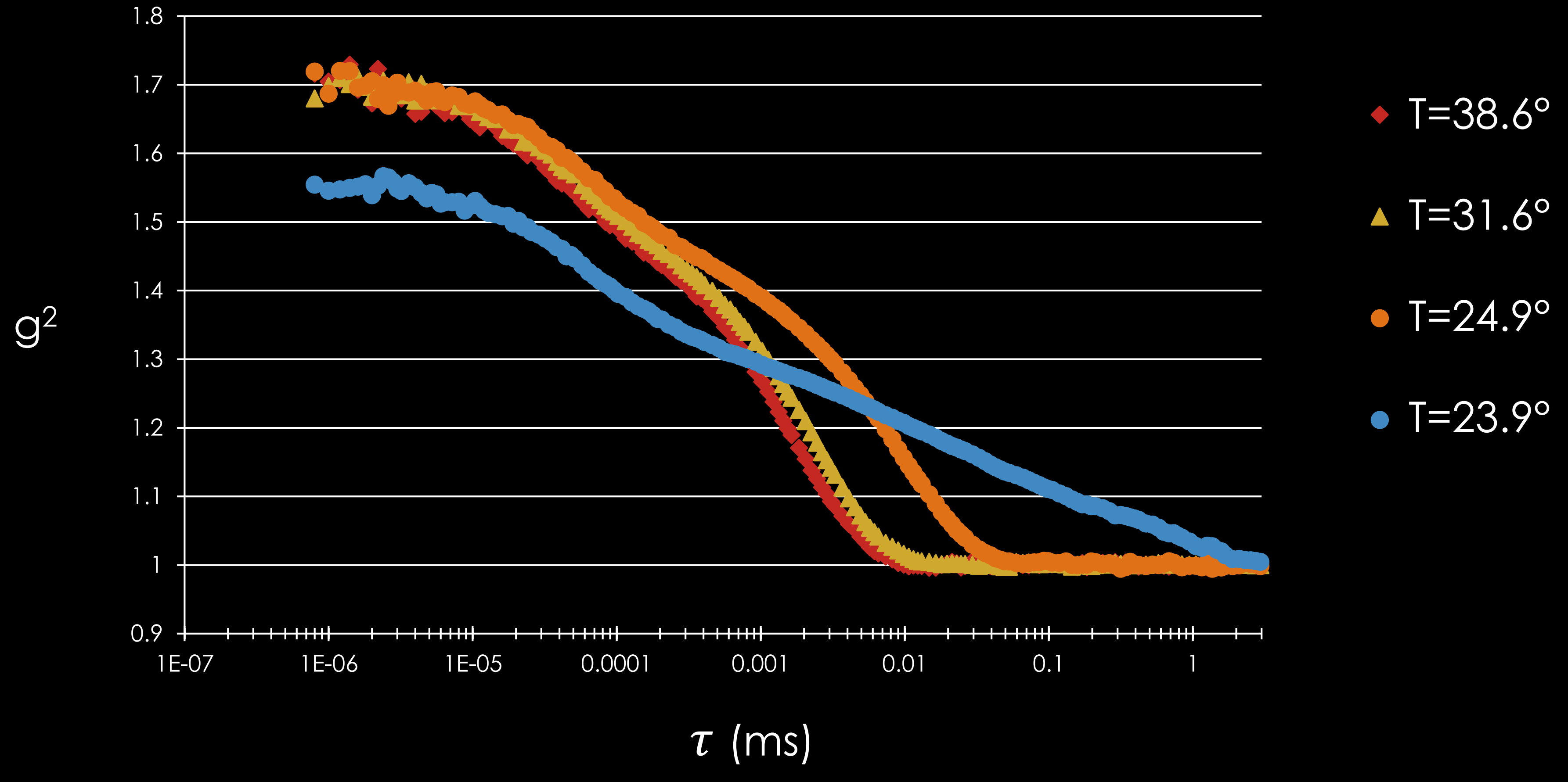
$\tau_c^{-1} = 2q^2D = 2q^2k_BT(6\eta\pi r)^{-1}$

$q = 4\pi n\lambda^{-1}\sin(\theta/2)$

$r = (16\pi/3)(n/\lambda)^2k_BT\eta^{-1}\sin^2(\theta/2)\,\tau_c$

Sorensen, Christopher (1987), *Photon Correlation Spectroscopy and its Application to Aerosol Systems* **4**

g^2 Function v. Tau



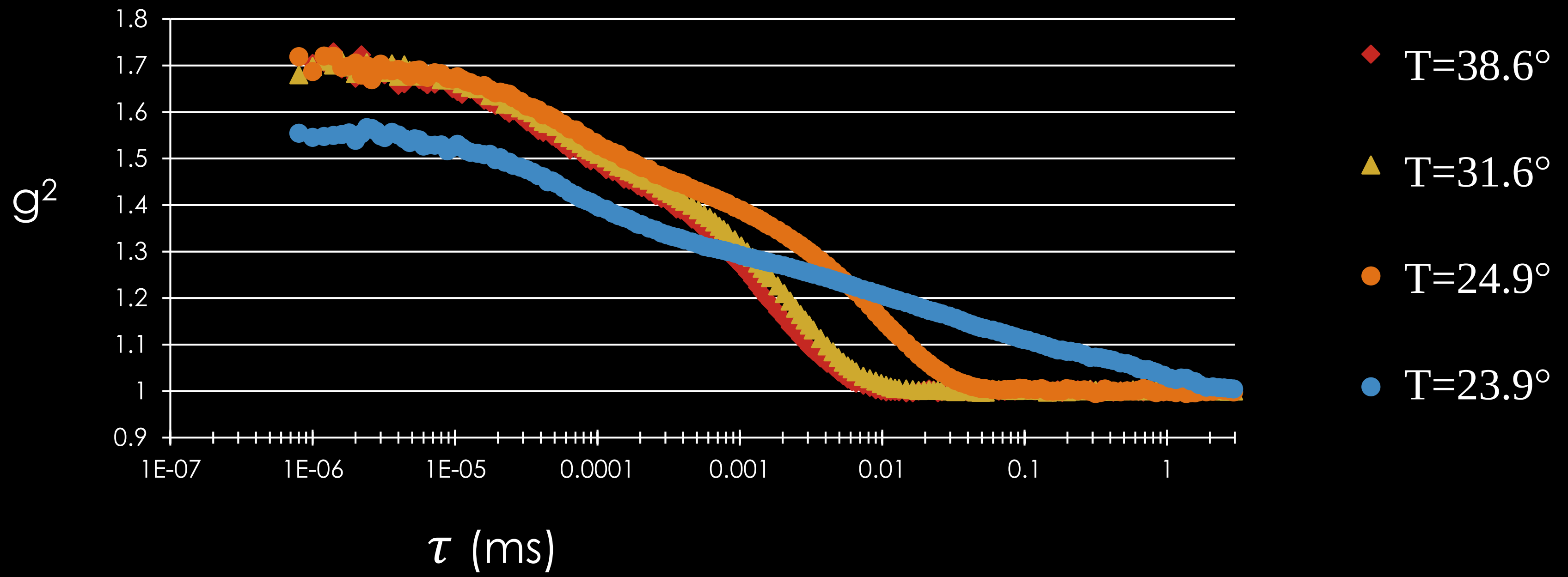
Data Interpretation

Field Correlation Function

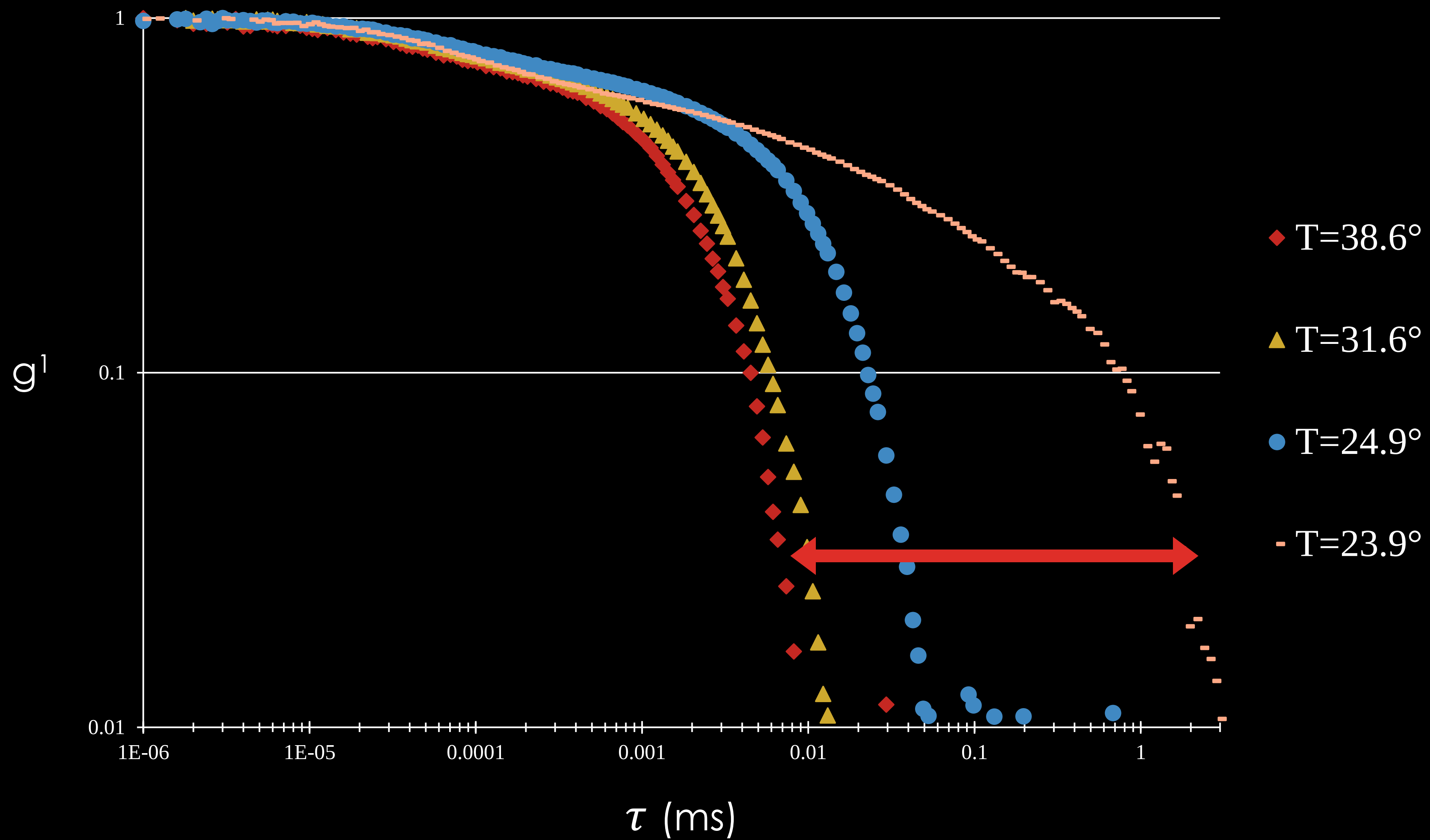
$$g^1(t) = [[\varphi(t) + 1 - \sigma]^{0.5} - (1-\sigma)^{0.5}]/[1-(1-\sigma)^{0.5}]$$

$$\varphi(t) = g^2(t) - 1$$

$$\sigma = \varphi(0) = g^2(0) - 1$$



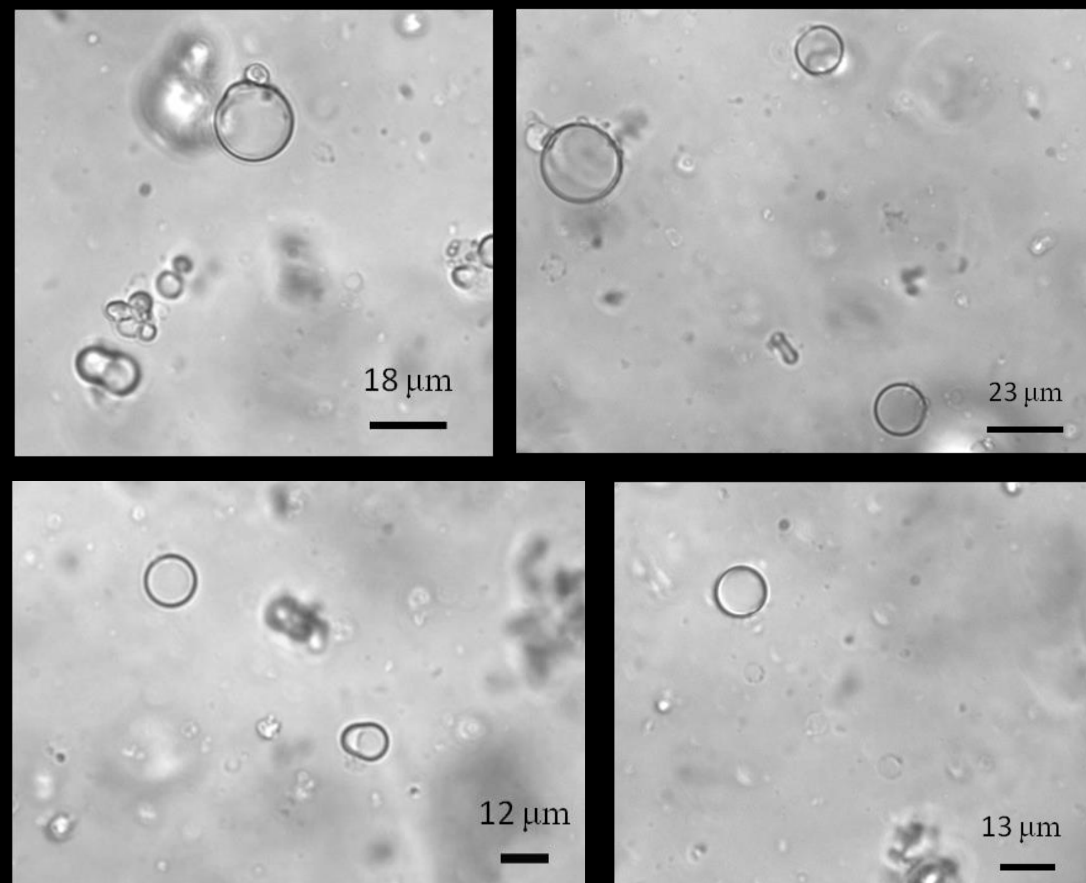
g^1 Function v. Tau



Relevance to Polymerization in Vesicles

- One method for analysis concerning polymerization in a vesicle

- Useful to characterize the statistical & coherent properties of electric fields

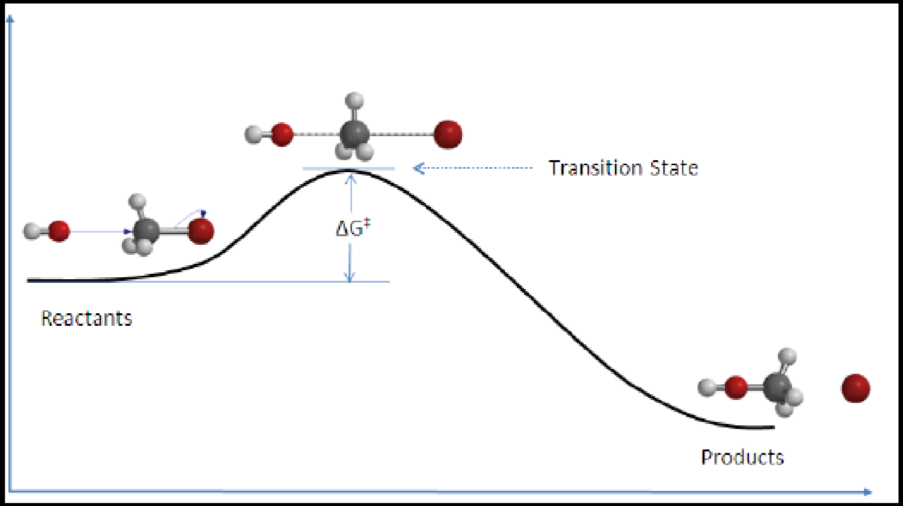


Catalytic Activity in a Vesicle

Requires a greater understanding of Potential and Electric Fields within and around the vesicle and reaction rate

- $k \sim e^{(-E_a/(k_b T))}$

Energy



Reaction Coordinate

Vesicle Potentials

V_{in}= 3σ2 σ3AEorb3cos(θ)

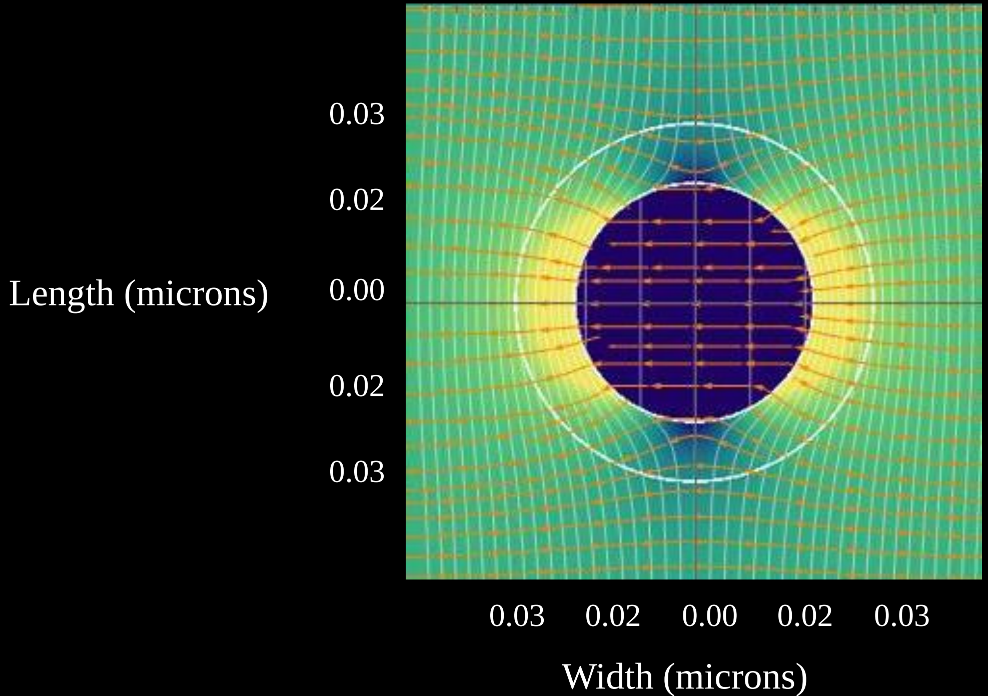
V_{mid}= σ3AEob3(2σ2+ σ1)rcos(θ)+σ3AEoa3b3(σ2-σ1)cos(θ)/r2

$V_{out}= -Arcos(\theta)+Ab^3 r^{-2}(1+A\sigma_3 b^3(2\sigma_2+ \sigma_1)+A\sigma_3 a^3(\sigma_2-\sigma_1)cos(\theta)$

Where:

$A= 3*[2a^3(\sigma_2-\sigma_1) (\sigma_2-\sigma_3)$

$-b^3(2\sigma_2+ \sigma_1) (2\sigma_3+ \sigma_2)$



Vesicle Electric Fields

$E_{in}= -3\sigma_2\ \sigma_3 A E_o b^3 \cos(\theta)$

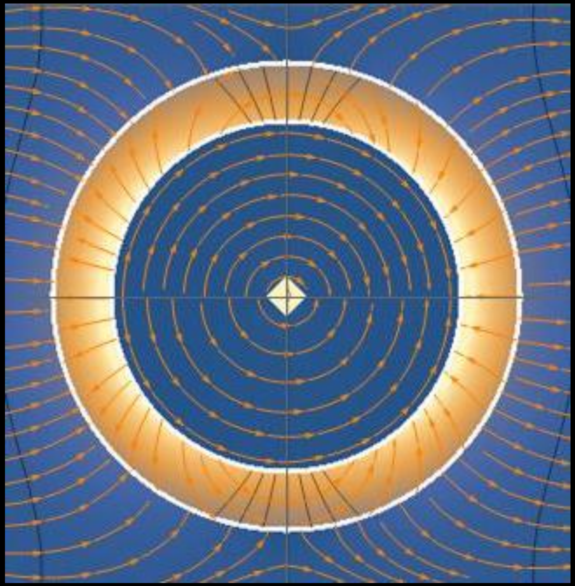
$E_{mid}= \sigma\text{-}_3 A E_o b^3(2\sigma_2+ \sigma_1)\cos(\theta)+2\sigma_3 A E_o a^3 b^3(\sigma_2-\sigma_1)\cos(\theta)/r^3$

$E_{out}= A\cos(\theta)+3Ab^3\ r^{-3}[(1+A\sigma_3 b^3(2\sigma_2+ \sigma_1)+A\sigma_3 a^3(\sigma_2-\sigma_1)]\cos(\theta)$

Where:

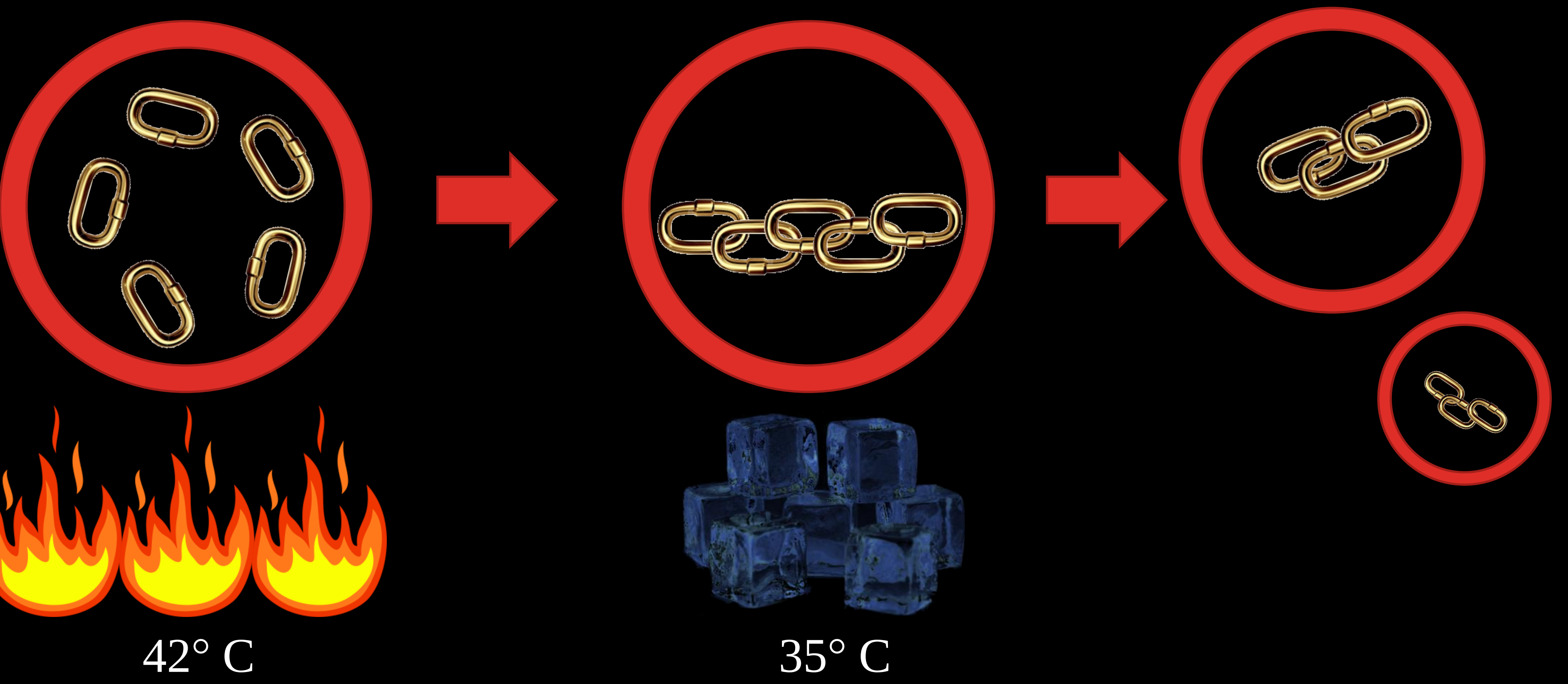
$A= 3*[2a^3(\sigma_2-\sigma_1)\ (\sigma_2-\sigma_3)$

$\quad -b^3(2\sigma_2+ \sigma_1)\ (2\sigma_3+ \sigma_2)$



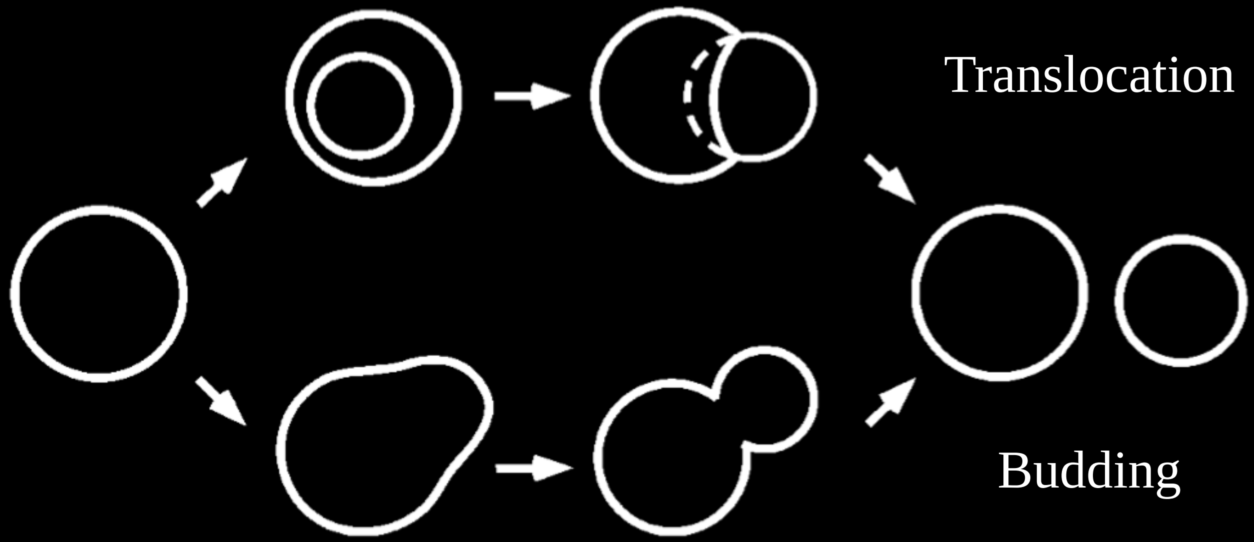
Self-Reproducing Model

Vesicle Heating



Self-Reproducing Model

- Take DPPC and/or DLPE Lipids and produce vesicles
  - Cycle the temperature from 35°C and 42°C and back again

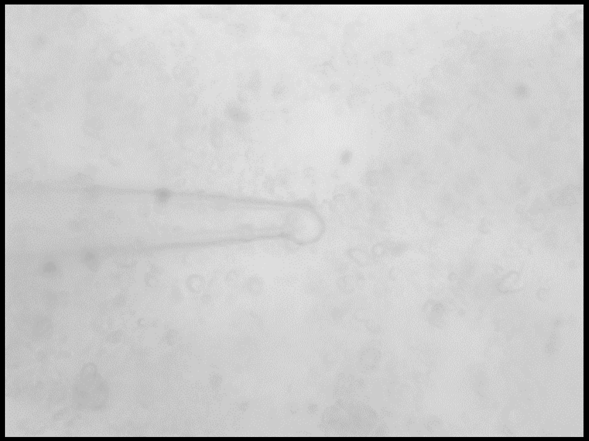


Sakuma & Imai (2011), *Model System of Self-Reproducing Vesicles* **Figure 1**

Results of Initial Tests Using DLPE:DPPC Vesicles

- DLPE:DPPC Vesicles (3:7)
    - Buffer Solution Only (no gelatin)

T=24.8° C



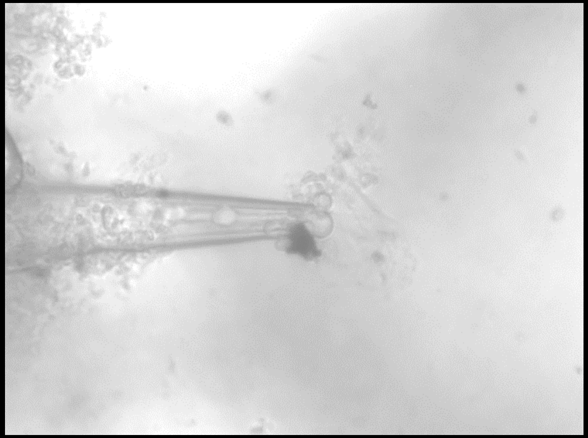
T=29.7° C

T=35.5° C

Results of Initial Tests Using DLPE:DPPC Vesicles

- DLPE:DPPC Vesicles (3:7)
  - Buffer Solution Only (no gelatin)

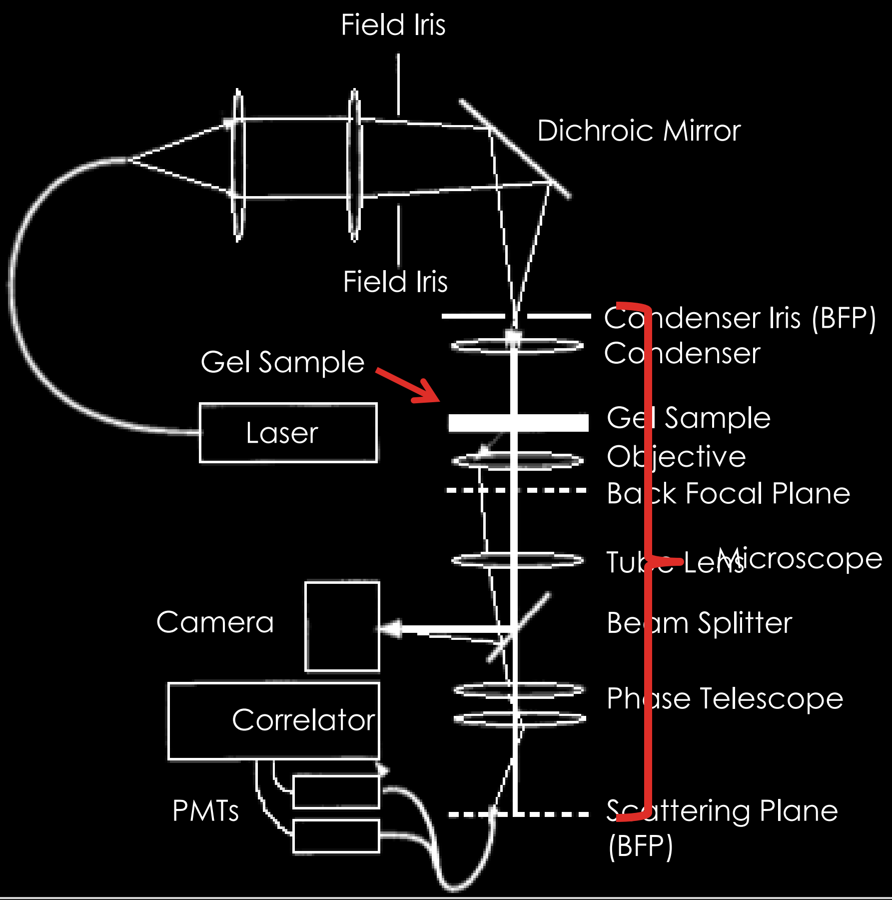
T=36.4° C



T=37.1° C

T=42.8° C

Simultaneous Dynamic Light Scattering & Imaging



Kaplan, Trappe, & Weitz (1999), *Light Scattering Microscope* **2**

Future Directions of Research

- Self-Reproducing Model of Vesicles (DLPE/DPPC lipids)
  - Temperature Cycling
  - Potential and Electric Vector Fields inside and outside of the vesicles
- Simultaneous DLS and Imaging Microscopy
  - While attempting to reproduce vesicles

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K·STATE Research and Extension

NSF