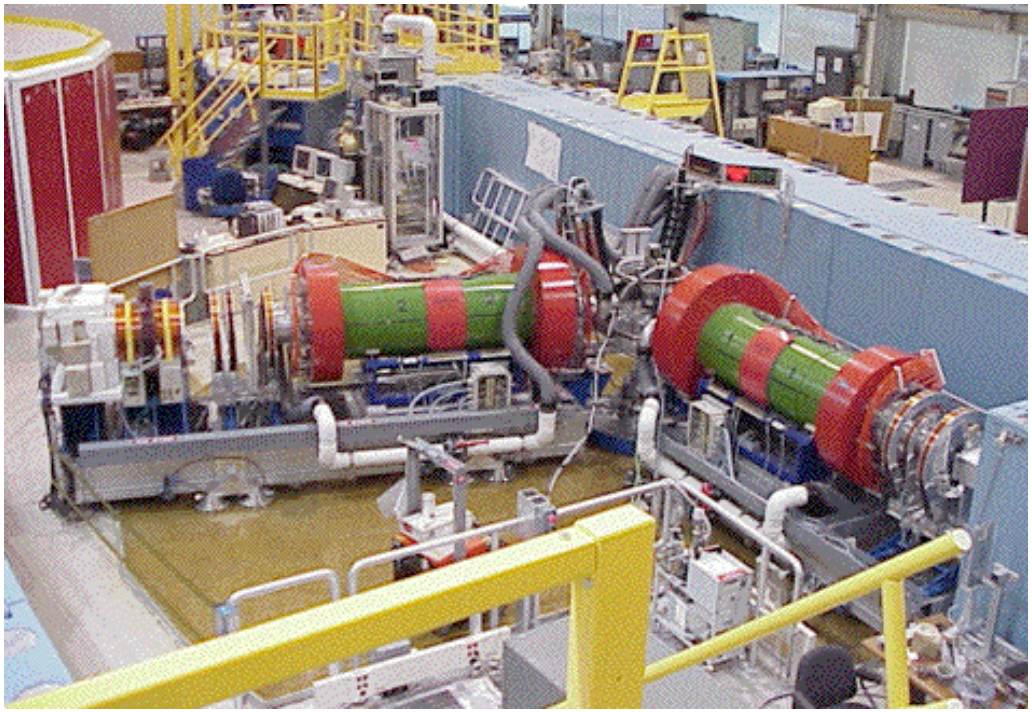
Neutron Spin Echo Spectroscopy (NSE)



Group B

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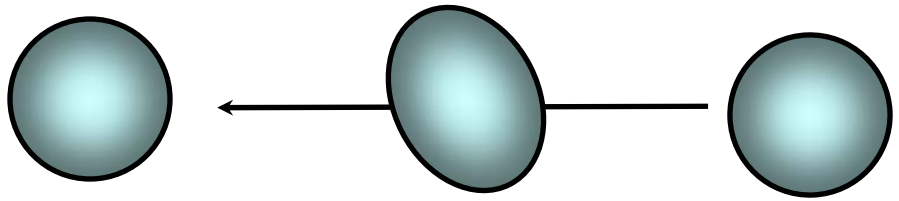
Dynamics of particles

Diffusion (T, η, ρ, R k)



- NMR (Pulsed Field Gradient)
μs and higher

- Dynamic light scattering
μs –ms, 1-100 nm

NSE
Time scale ~ 1 - 10 ns
Size scale 1-100 Å

↓

shape fluctuations

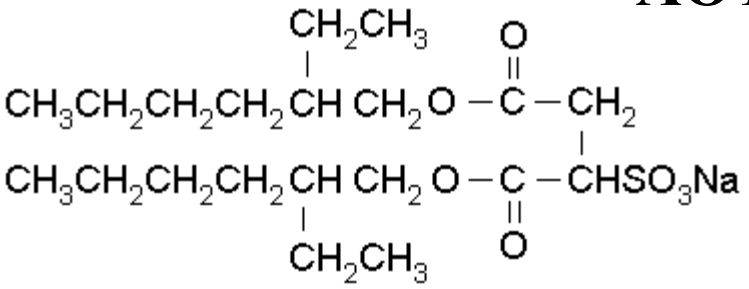
↓

Spontaneous curvature,
bending elasticity,

Experiment

Surfactant molecule

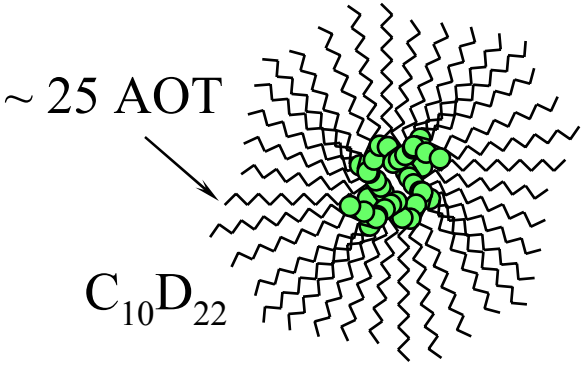
AOT



Experiment I

of AOT micelles in $C_{10}D_{22}$
(5.4 % vol. fraction)

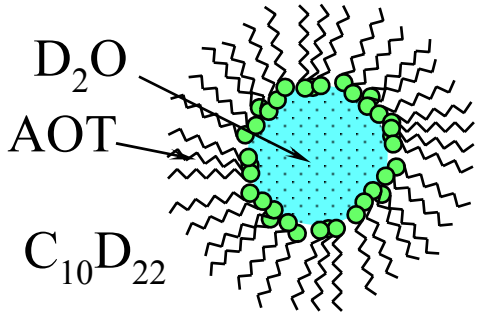
Inverse spherical micelle



Experiment II

$AOT/D_2O/C_{10}D_{22}$
(5.4/4.6/90 % vol. fraction)

Inverse microemulsion droplet

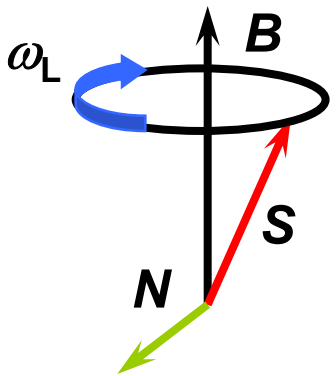


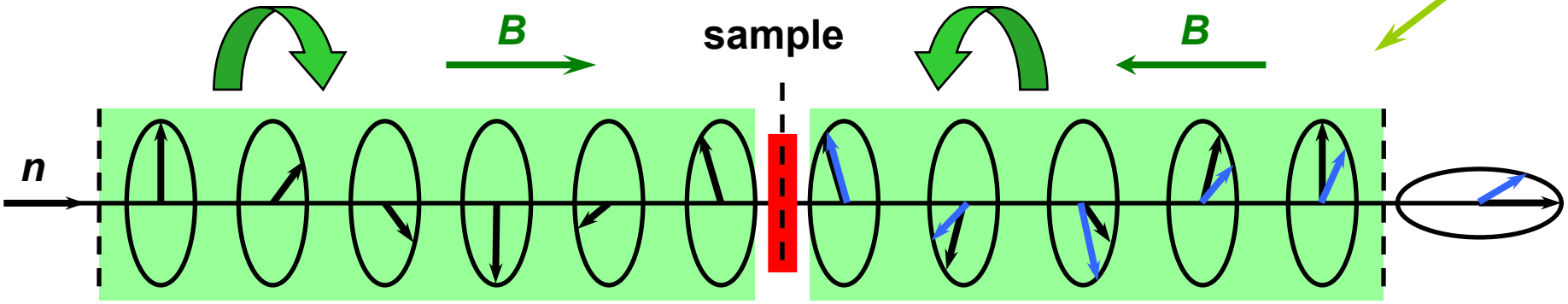
Principle of NSE

Neutrons posses spin and magnetic moment. They precess in magnetic fields with the Larmor frequency that depends on the strangth of the magnetic field only. (g =1.83×10^{8} s^{-1}T^{-1})

$$N = S \times B$$

$$\omega_L = gB$$





Angle **0** φ • **elastic scattering** φ **0** **<cos(±Δφ)>**

• **inelastic scattering** φ $\pm\Delta\varphi$

$$\varphi = gB\frac{L}{V} \qquad \Delta\varphi = gBL\left(\frac{1}{V}-\frac{1}{V'}\right) = \frac{gBL\Delta V}{V^2}$$

$$\frac{\Delta V}{V} \approx 10^{-5}\ !$$

$$\langle P \rangle = \left\langle \int_{-\infty}^{\infty} S(\mathbf{Q},\omega)\cos(\omega t)d\omega \right\rangle = I(Q,t)$$

Goal

Experiment I

AOT micelles in $C_{10}D_{22}$ $\longrightarrow$ $\frac{I(Q,t)}{I(Q,0)} = \exp\left[-D_{eff} Q^2 t\right]$

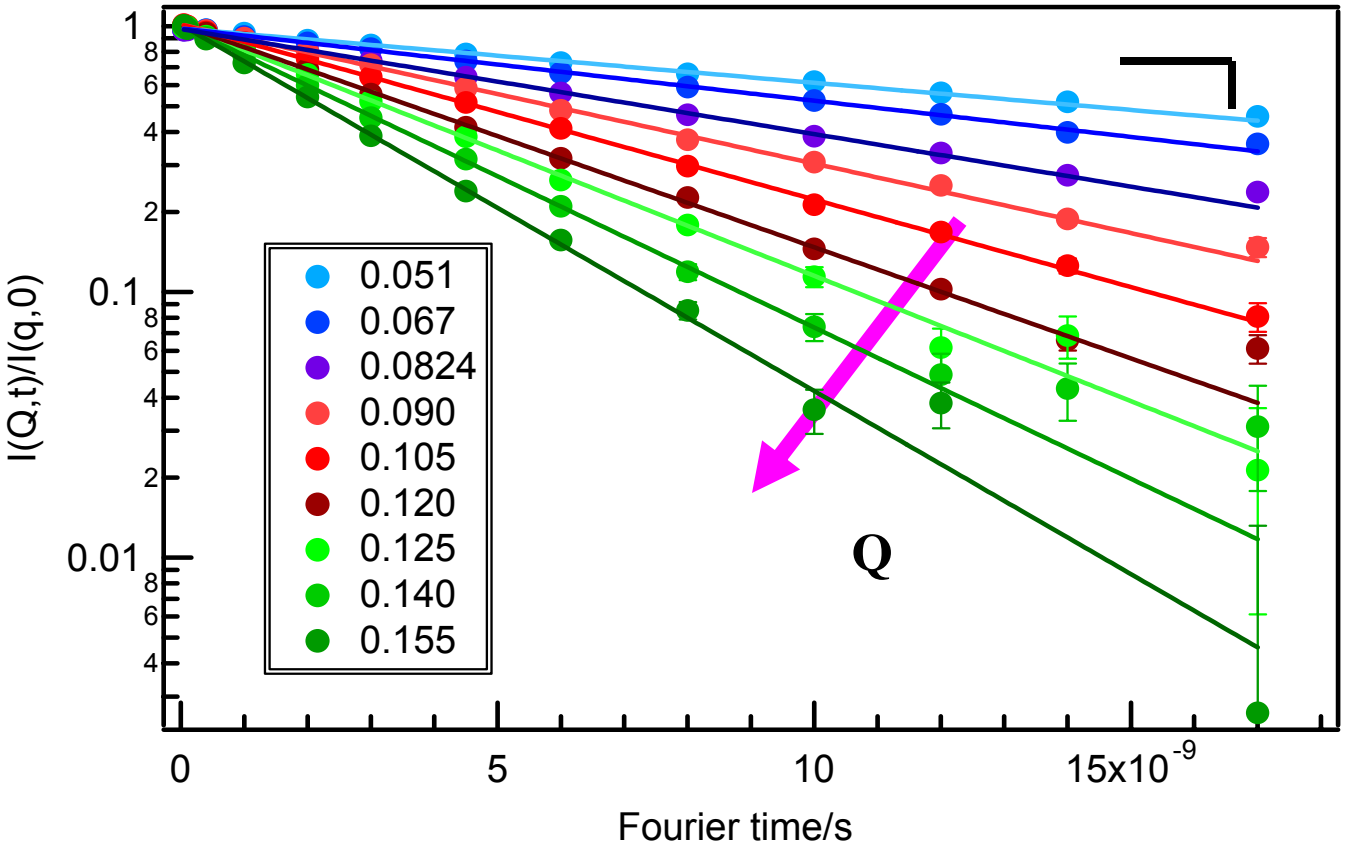
Experiment II

$AOT/D_2O/C_{10}D_{22}$ microemulsion $\longrightarrow$ $\frac{I(Q,t)}{I(Q,0)} = \exp\left[-D_{eff}(Q) Q^2 t\right]$

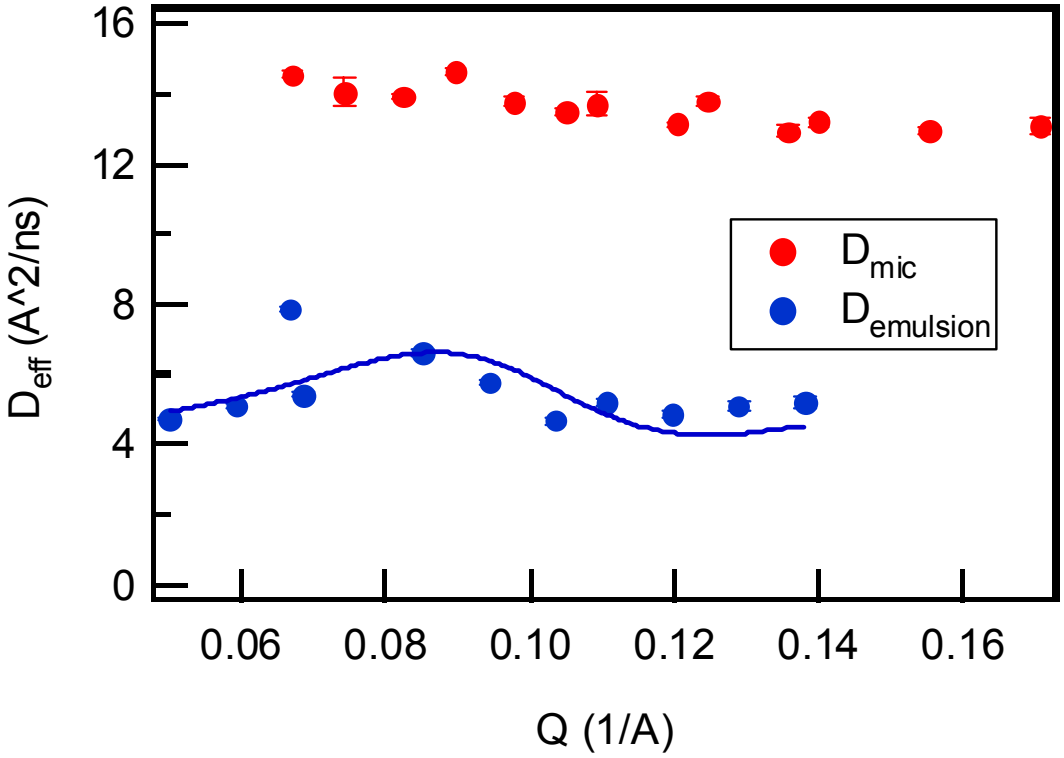
$$D_{eff}(Q) = D_{tr} + D_{def}(Q)$$

Results

$$\frac{I(Q,t)}{I(Q,0)} = \exp\left[-D_{eff} Q^2 t\right]$$



Results



Damping frequency (Hz), $\mathbf{a_2}$	1.51×10^7
Amplitude, λ_2	0.039
D_{trans} (Å^2/ns)	4.2
Mean Radius(Å), $\mathbf{R_0}$	34.0-35.0
Bending elastic constant, k	$0.15 k_B T$

$$D_{eff}(Q) = D_{tr} + \frac{5\lambda_2 f_2(QR_0)\left\langle |a_2|^2 \right\rangle}{Q^2\left[4\pi\left[j_0(QR_0)\right]^2 + 5 f_2(QR_0)\left\langle |a_2|^2 \right\rangle\right]}$$

$$D_{tr} \approx 14 \quad \text{Å}^2/\text{ns}$$

$$R_H = \frac{(1-\varphi)k_B T}{6\pi\eta_0 D_{tr}}$$

$$R_H = 15.9 \quad \text{Å}$$

$$k = \frac{1}{48}\left[\frac{k_B T}{\pi p^2} + \lambda_2 \eta R_0^3 \frac{23\eta' + 32\eta}{3\eta}\right]$$

Conclusion

NSE is suitable for studies on:

Diffusion of micelles/microemulsion
Form Deformation

	Rg (Å) SANS	R_H (Å) NSE
Micelles	15.9	16.6
Micro Emul.	35.0	40.0

Micelles	K_BT
AOT (25C)	0.15
SOPC (18C)	0.9
DAPC (5,6,7C)	0.44

http://dept.physics.upenn.edu/
~pcn/mcgraw2/mcglatex.html

Acknowledgement

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NCNR, NIST