Shape Fluctuations of a Spherical Surfactant Shell in a Microemulsion

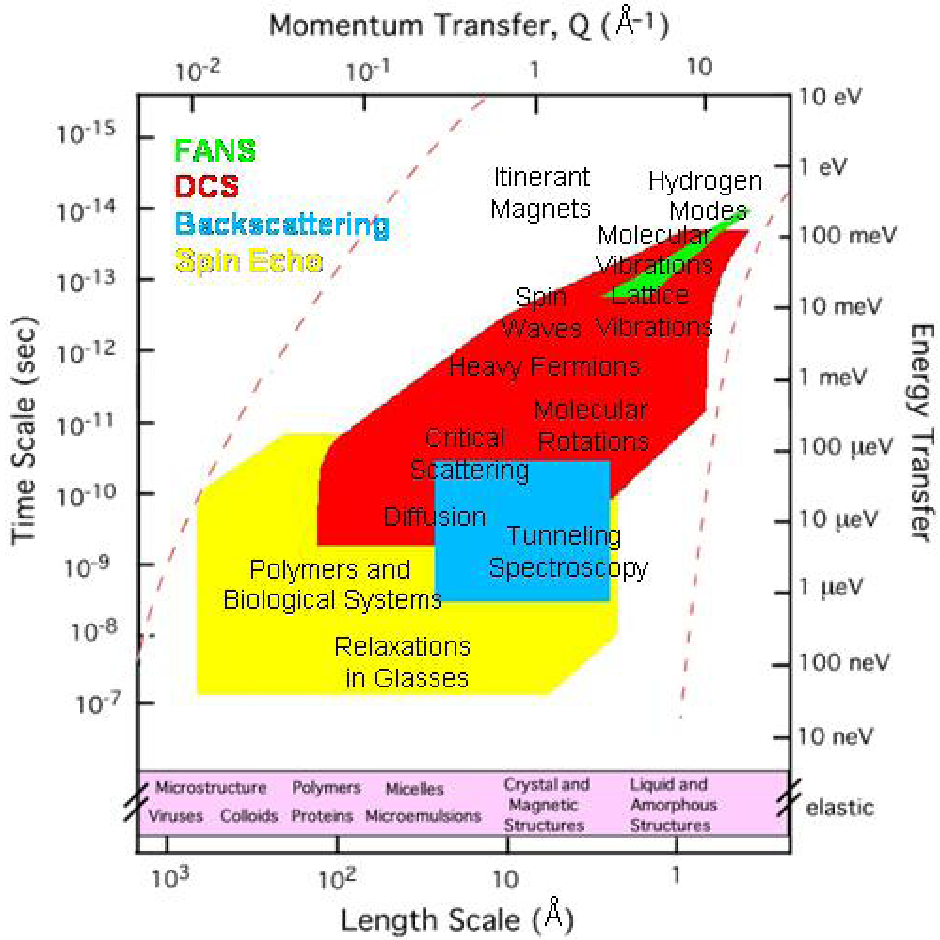
THE A-TEAM

Mike, Patryk, Vicki, Khiza, Maria, Greg, Steve & FengFeng

Outline

- NSE Basics
- Dynamics in a Microemulsion
- Spin Echo Geometry
- Measurement Technique
- Data Analysis
- Conclusion

NSE Basics



- Highest Energy Resolution (< μeV)
- Working in time domain (resolution can be divided)
- Suited for things that move/relax slowly (1 ps<t<100's ns) (1 Å <L<100 Å)

Determine static structure prior to investigating dynamics!

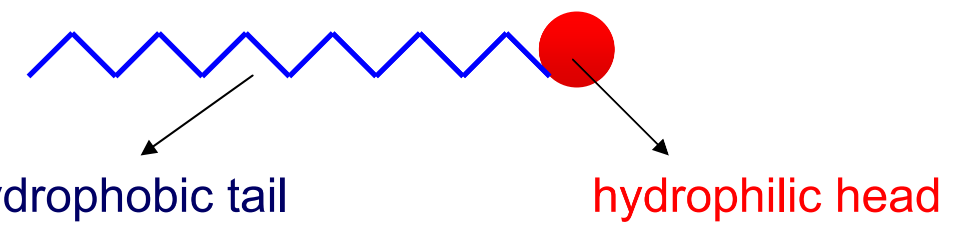
We want to study the dynamics of the surfactant shell in a microemulsion

What is a microemulsion?

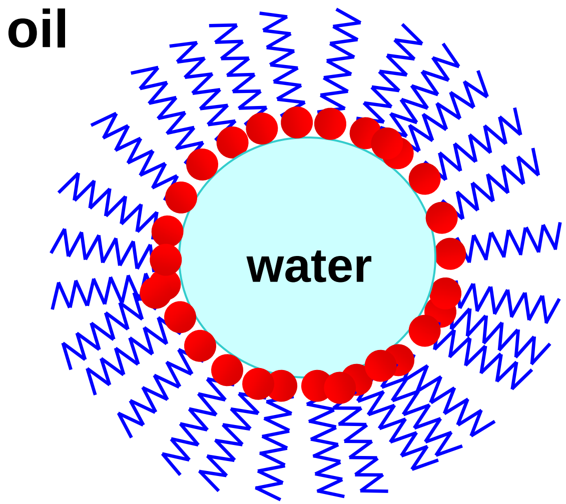
What dynamics of the microemulsion do we want to study?

microemulsion= surfactant + two inmiscible phases

SURFACTANT



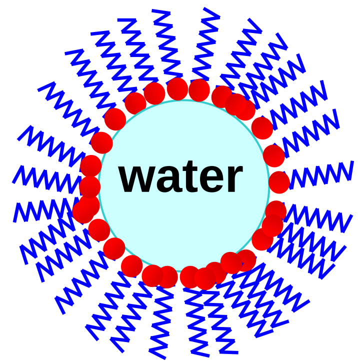
We are interested in studying <u>two dynamical processes</u>



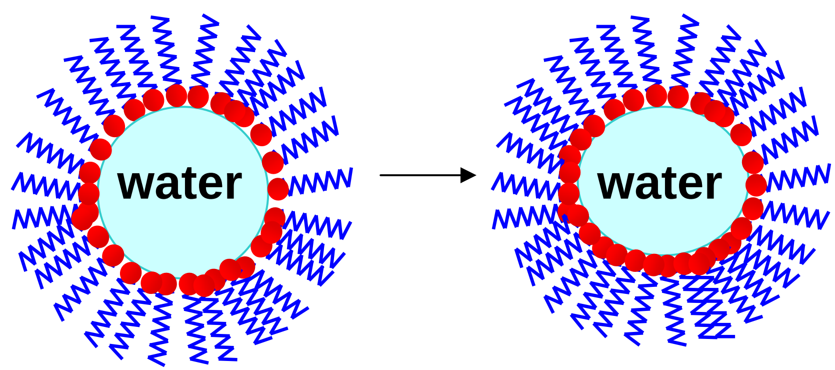
Focus on **COLLECTIVE MOTIONS**

Both processes lay in the dynamical range of NSE

1. Diffusion

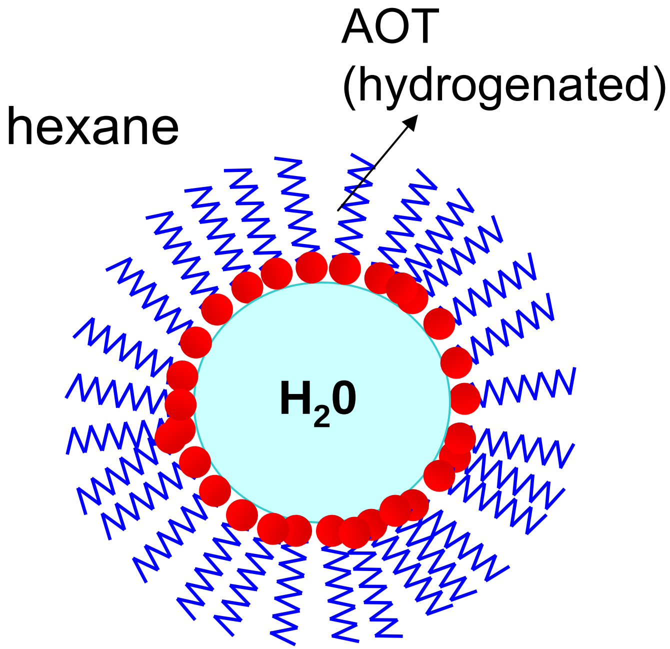


2. Shell shape fluctuations



Flexibility of the shell, bending modulus

Our system

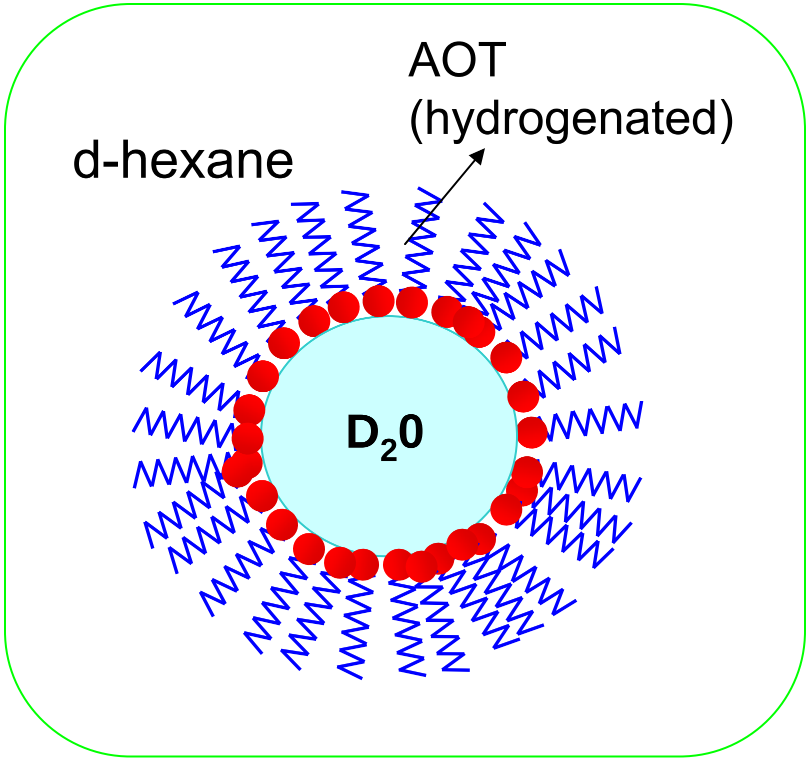


We want to study the shell…

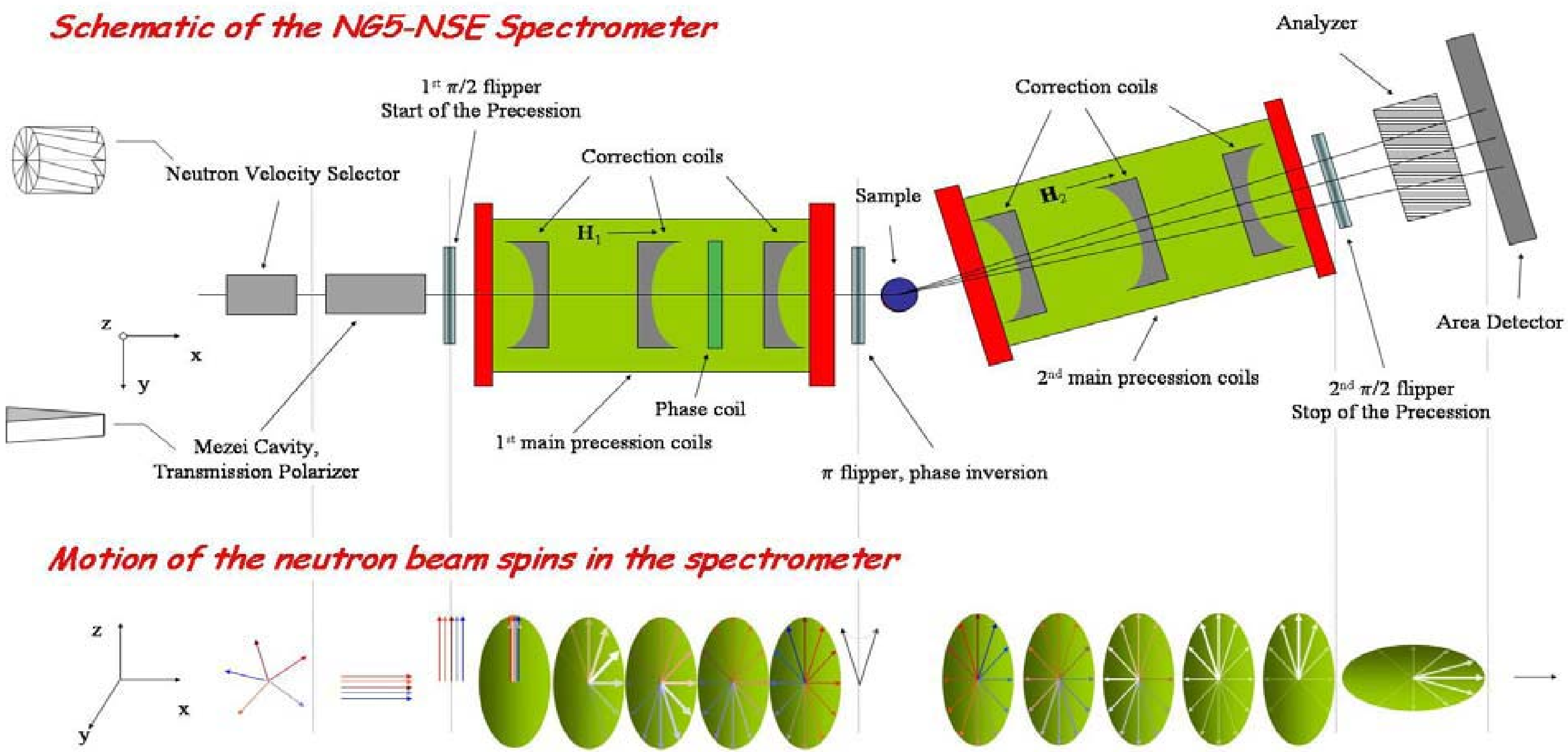
need to highlight the shell…

reduce incoherent scattering (background)

Contrast variation



Spin Echo Geometry



Measurement Setup

Instrument Capabilities:

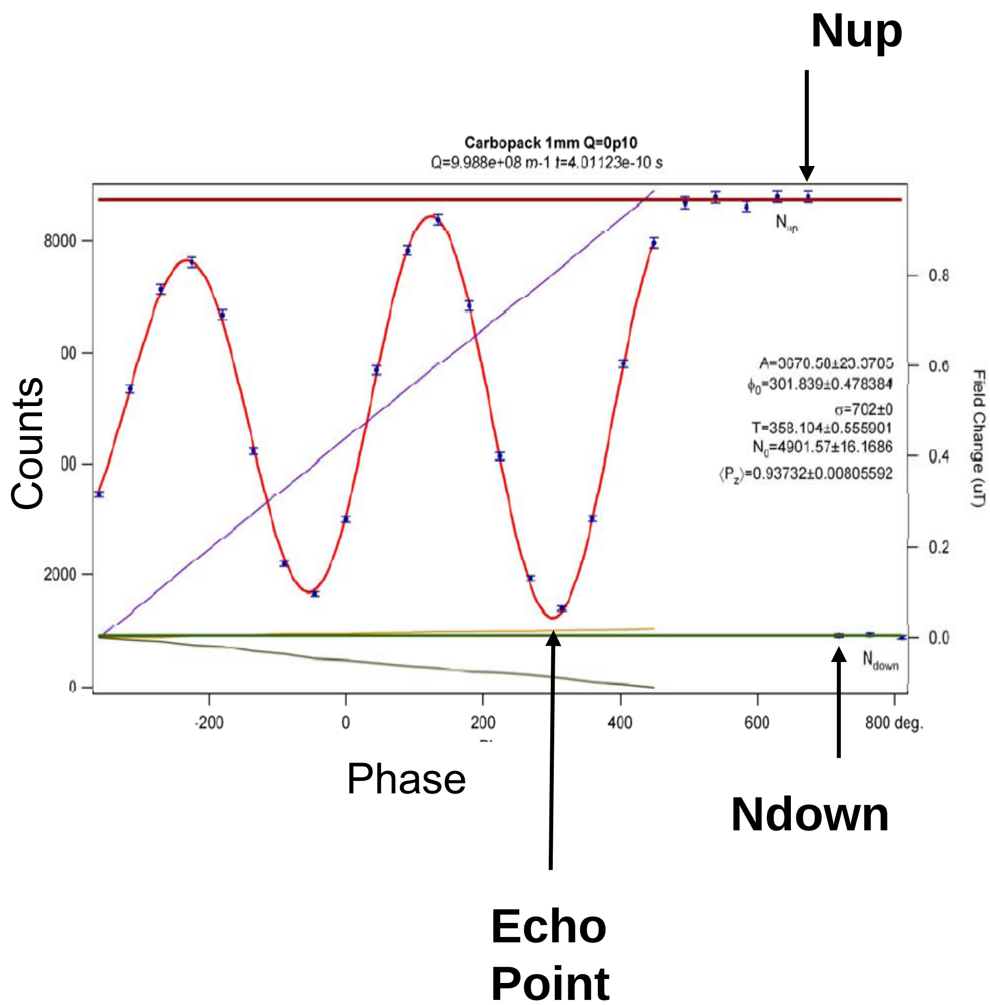
- Range of approximately 0.01 A^-1 to 1.6 A^-1
- Time scale from approximately 1 ps to 100 ns

Experimental Setup:

- Want to obtain:
  - Diffusion information
  - Dynamic Shape Information
- Selected Q values from 0.06 to 0.15 A^-1 (step size 0.03)
- Expected time range from 0.05 to 15ns
- Relaxation time decays exponentially
- Selected 3-4 time points per decade

Measurement Technique: The Echo Condition

- When I1 =I2
- How this is done:
  - Fix neutron wavelength and q value
  - Counting rate is measured for non spin-flipped neutrons (Nup), spin flipped neutrons (Ndown), and different phase current values,
  - Fit phase current data to damped cosine function and determine maximum echo amplitude to get echo point
  - Phase current gives position of echo point, amplitude gives information on dynamics
  - Make time measurements at the echo point
  - Repeat for different q value



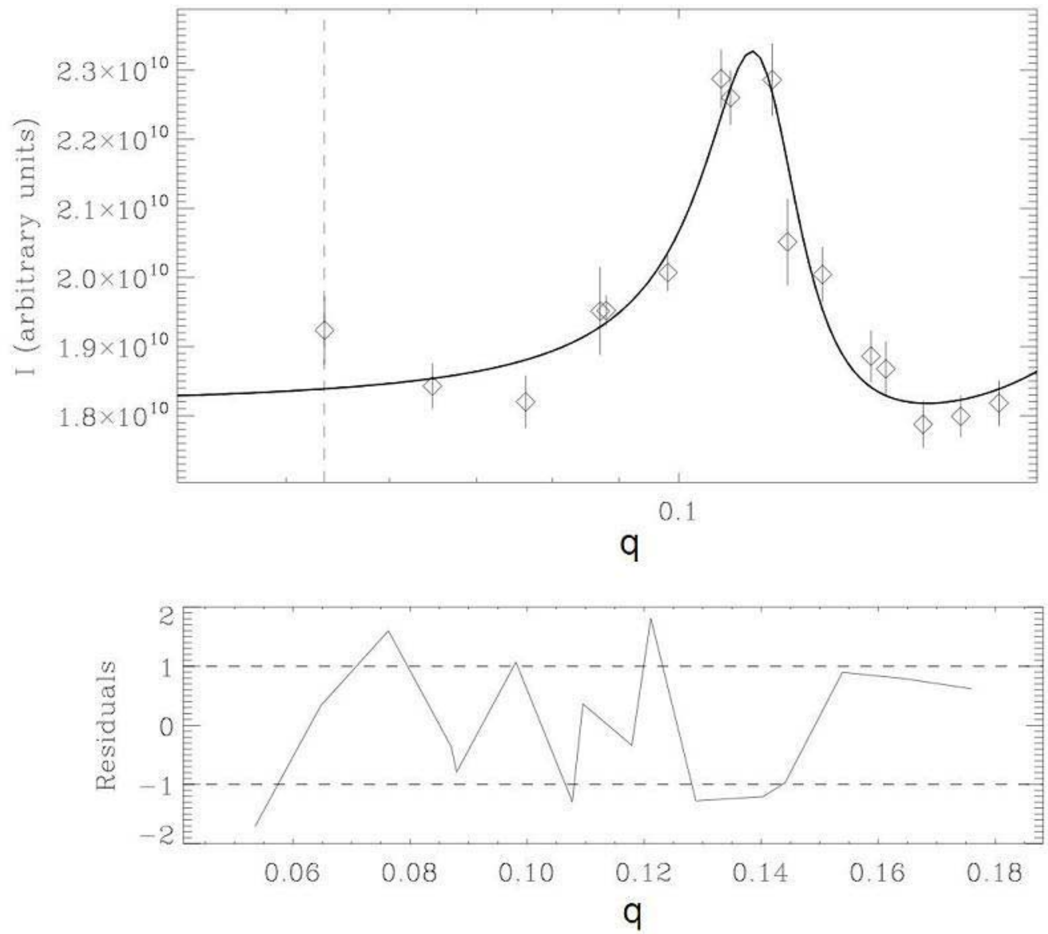
Analysis of NSE Data

- For an NSE experiment, the raw data is a 3-D plot of intensity vs phase current (our "spin echo") as a function of (Fourier) time

- Fit this data to obtain our parameters, including the D_{TR} ~ $1.818 \times 10^{10} \pm 1.5 \times 10^{8}$ Å^2/sec, and the damping frequency of droplet deformation, $6.67 \times 10^{7} \pm 5.22 \times 10^{6}$ sec^{-1}.

Shape fluctuations of AOT micelle

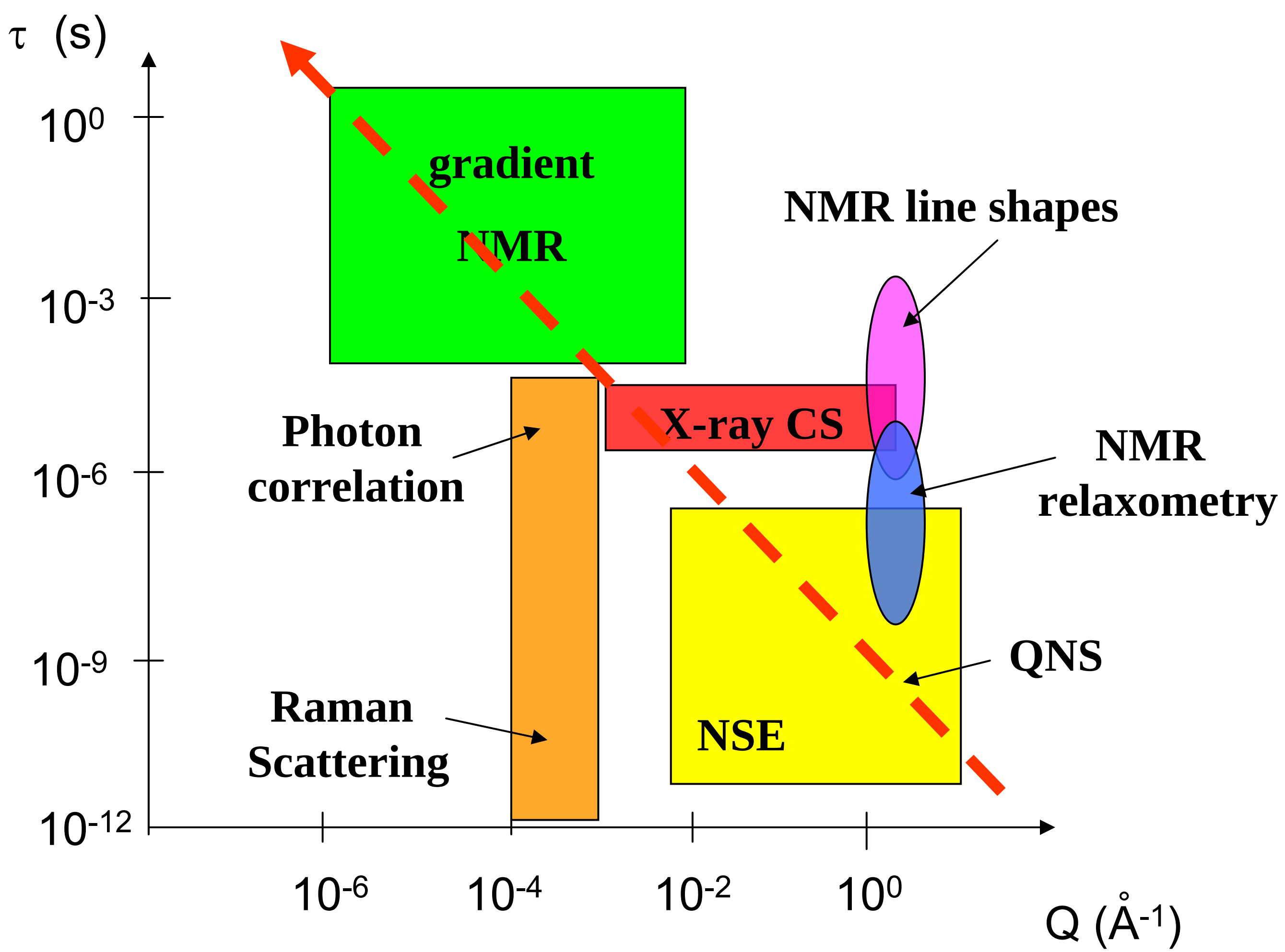
- Radius of core & micelle (as determined by SANS) is ~ 28.4 Å (q ~ 0.11 $Å^{-1}$)
- Observe feature in the NSE data between q ~ 0.11 to 0.13 $Å^{-1}$, corresponding to distortions in the micelle shape



Elasticity of the AOT film

- Bending modulus of the AOT film is given by the equation: $k = (1/48)[(k_BT/\pi p^2)+(\lambda_2\eta R_0^3)(23\eta'+32\eta/3\eta)]$ after a fair bit of mathematics.
- The polydispersity, p, is obtained from the SANS measurement, and λ_2, the damping frequency of the droplet deformation, is obtained from the fitting of the NSE data.
- $k = 1.09 \times 10^{-21}$ J, or equivalently, $0.265{*}k_BT$.

Working regimes of NSE and other methods



Conclusions

- NSE: valuable information about dynamics in terms of different parts of the microemulsion
- Neutron spin echo yields information about microemulsion dynamics on a microscopic scale
- Exponential form of correlation functions proposed by Milner and Safran, explains satisfactory relaxation processes in the investigated systems
- The presented approach provides valuable information about dynamics in terms of two types of motion, diffusion and shape fluctuation
- Results of the diffusion coefficient consistent with NMR measurements

Acknowledgements