DETERMINATION OF PARTICLE SIZE BY DYNAMIC LIGHT SCATTERING

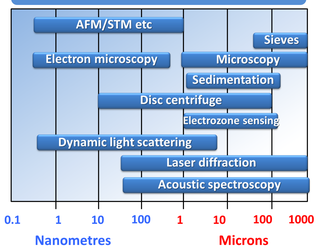
Introduction

Dynamic light scattering is a non-invasive technique that detects the fluctuations of the scattering intensity due to the Brownian motion of particles in solution (Pecora, 1985).

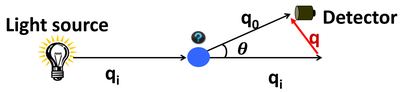
It can be used to determine:

- Particle size
- Size distribution
- Relaxations in complex fluids

Size characterization techniques



Light scattering event

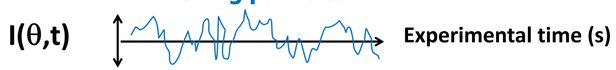


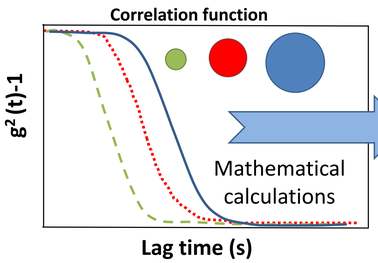
Scattering vector $|q| = \frac{4\pi n}{\lambda}\sin\left(\frac{\theta}{2}\right)$

$n \rightarrow refractive\ index$
$\lambda \rightarrow wavelength$

DLS measurements

Moving particles





Diffusion coefficient, D_m

Stokes-Einstein

$$D_m = \frac{k_B T}{3\pi\eta d_h}$$

k_B: Boltzman constant *η: viscosity*
T: temperature (Kelvin) *d_h: hydrodynamic diameter*

$$G^{(2)}(t) = B\left(1 + f\left|g^{(-1)}(t)\right|^2\right)$$

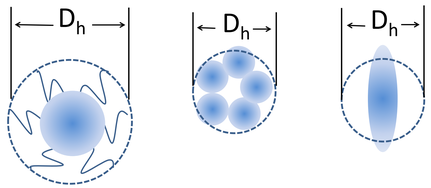
$$g^{(1)}(t) = e^{-\Gamma t}$$

$$\Gamma = \tau^{-1} = q^2 D_m$$

B: intercept *q: scattering vector*
Γ: decay constant *D_m: diffusion coefficient*
τ: lag time

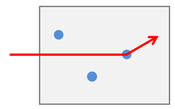
Hydrodynamic diameter

Diameter of an ideal sphere that diffuses at the same speed as the particle or molecule being measured.



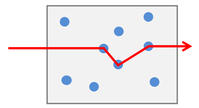
Cross-Correlation Technology

Single scattering

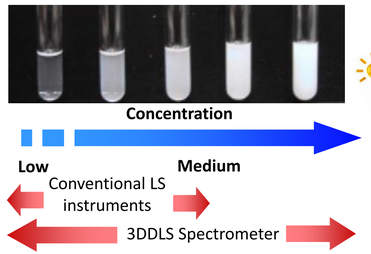


Light is only scattered by one scattering event: **single scattering**.

Multiple scattering



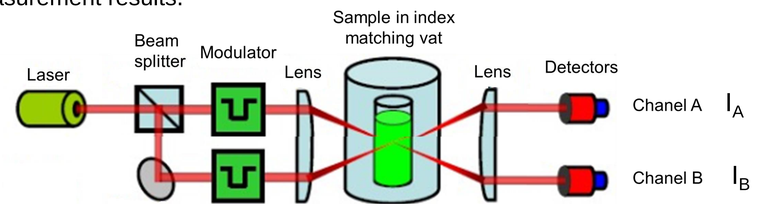
Light is scattered by several scattering events: **multiple scattering**.



Multiple scattering increases with concentration.

Diluting samples may change effective particle size due to changes in colloidal stability, structure and surface charge.

Two monochromatic and coherent laser beams are focused in a test sample. The two light beams cross each other within the test sample. The overlap of the two laser beams forms the scattering volume. Light scattered by the particles is detected at a fixed angle by two detectors. Thus, two independent scattering measurements are performed at the same scattering volume. This allows the identification of multiple scattering and supresses it on the measurement results.



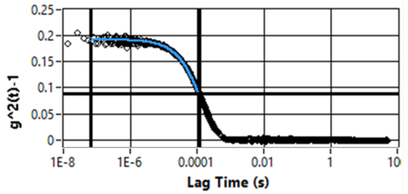
If the intensity measured by the detectors, **I**, is:

$I_A = I_B$	The signal detected is correlated with the signal from the laser source
$I_A = I_B = I_{Laser}$	The signal detected is the un-scattered laser
$I_A \neq I_B$	The signal detected is not correlated with the signal from the source (multiple scattering signal)

Data analysis

CUMULANTS METHOD

This analysis only gives a mean particle size and an estimate of the width of the distribution (polydispersity index). A monomodal size distribution is assumed and a single exponential fit is applied to the autocorrelation function.



Cumulant Analysis

	Radius	Intercept
		0.192
1st Ord.	24.93 nm	Width
2nd Ord.	25.05 nm	3.12 nm
3rd Ord.	25.35 nm	8.98 nm

POLYDISPERSITY INDEX

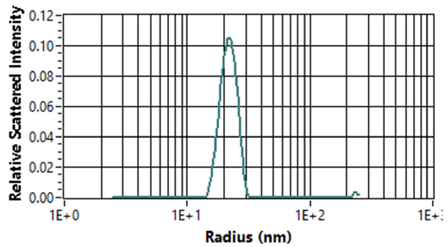
A dimensionless measure of the broadness of the size distribution calculated from the cumulant analysis.

$$PI = \frac{width}{2nd\ order\ radius}$$

In terms of a protein analysis, a % polydispersity less than 20% indicates that the sample is “monodisperse”.

CONTIN METHOD

If a single exponential decay is not sufficient to fit the data, a distribution function is performed (Provencher, 1982).



References

Pecora, R., Dynamic Light Scattering: Applications of Photon Correlation Spectroscopy, Plenum Press, 1985.

Provencher, S.W., CONTIN: A general purpose constrained regularization program for inverting noisy linear algebraic and integral equations, Comp. Phys. Comm. 27,(3), 229-242, 1982.