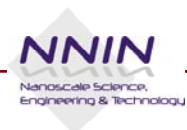




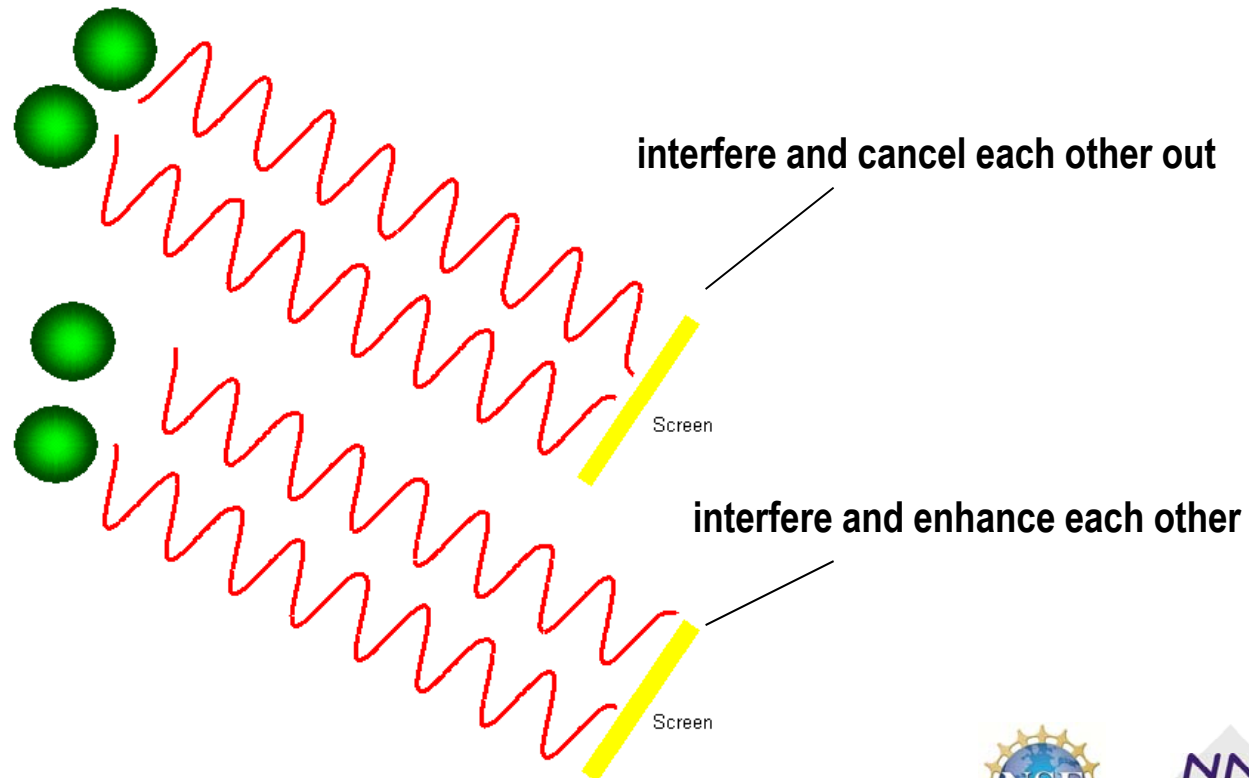
## Dynamic Light Scattering (DLS)

- **What's it for:** measuring the size of particles typically in the sub micron region, also referred to as Photon Correlation Spectroscopy or Quasi-Elastic Light Scattering.
- **How it works:** particles suspended within a liquid undergo Brownian Motion. The larger the particle, the slower the Brownian motion will be. DLS monitors the Brownian Motion with light scattering.
- **Other functions:** measuring the zeta potential of a particle and measuring or estimating the molecular weight of organic compounds.

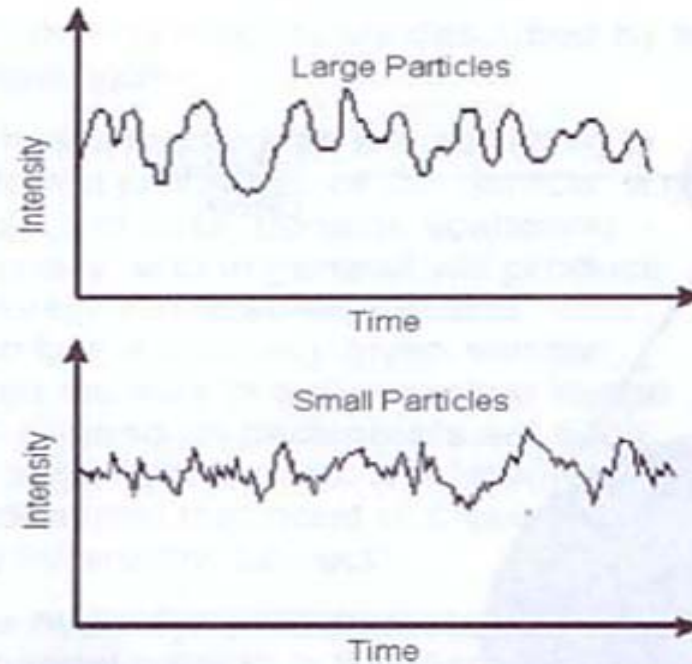


## DLS Measurement – Scattered Light Intensity Fluctuation

- **DLS Measurement:** the speed at which the particles are diffusing due to Brownian motion is measured by recording the rate at which the intensity of the scattered light fluctuates.
- **Phase addition of scattered light**



## DLS Measurement – Scattered Light Intensity Fluctuation



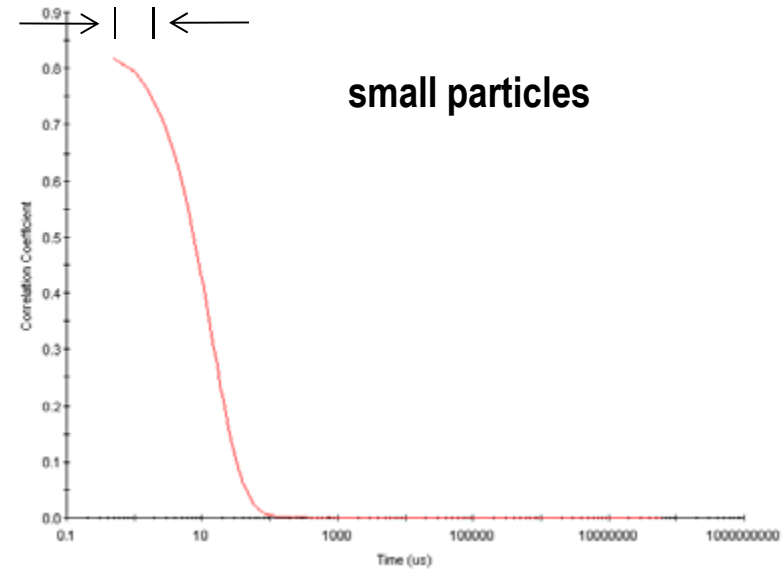
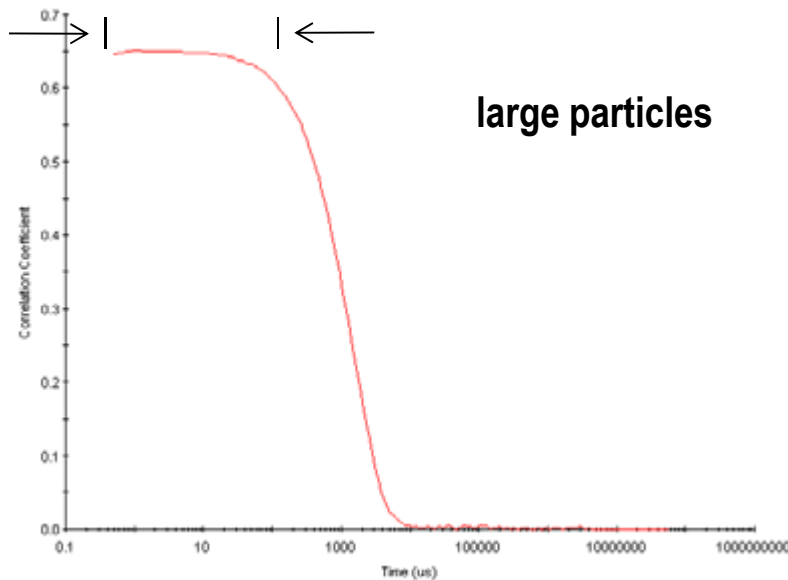
**Figure 4:** Typical intensity fluctuations for large and small particles

- Smaller particles cause the intensity to fluctuate more rapidly than large particles.

## Correlator – Monitor Light Intensity Fluctuation

- Compare the intensity of signal at time =  $t$  to the intensity a very small time later ( $t+\delta t$ )

$$G(\tau) = \langle I(t) \cdot I(t+\tau) \rangle$$



- Larger particles in which the correlation of the signal takes a long time to decay.
- Small particles move more rapidly so correlation decreases more quickly

## Correlation Function

- Correlation function:

$$G(\tau) = \langle I(t) \cdot I(t+\tau) \rangle$$

- Monodisperse particles: cumulants analysis

$$G(\tau) = A[1 + B \exp(-2\Gamma\tau)]$$

$$\Gamma = Dq^2$$

↓ refractive index of dispersant

$$q = (4 \pi n / \lambda_0) \sin (\theta/2)$$

**D=Translational diffusion Coefficient (The velocity of the Brownian motion is defined by a property known as the translational diffusion coefficient )**

- Polydisperse particles: non-negative least squares (NNLS) or CONTIN

$$G(\tau) = A[1 + B \sum g_i(\tau)^2]$$

↗ sum of all the exponential decays

## Principles of DLS

- Particle size is given in terms of hydrodynamic radius
- **Hydrodynamic Radius:** the diameter of a sphere that has the same translational diffusion coefficient as the particle

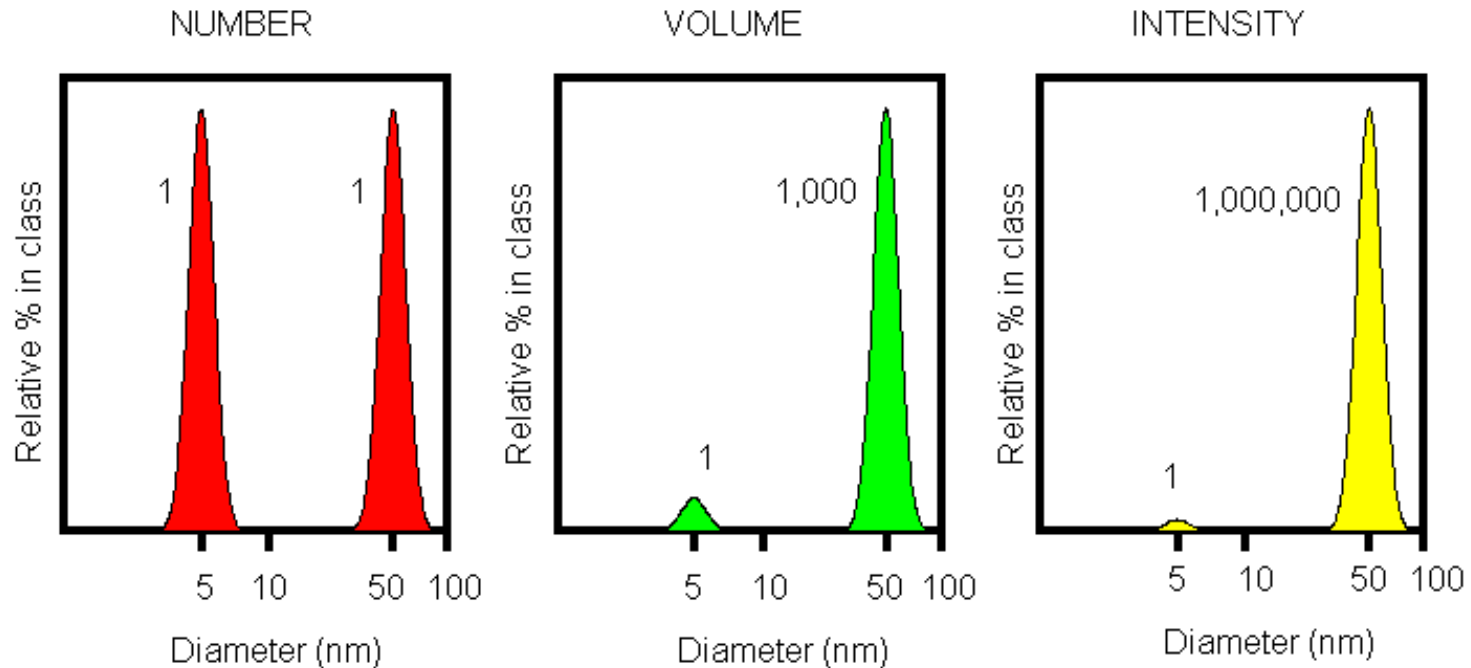
### Stokes-Einstein equation

$$d(H) = \frac{kT}{3\pi\eta D}$$

Boltzmann's constant  $k$       absolute temperature  $T$   
 viscosity  $\eta$       translational diffusion coefficient  $D$   
 – velocity of Brownian Motion

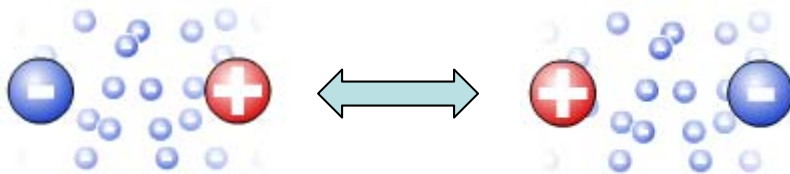
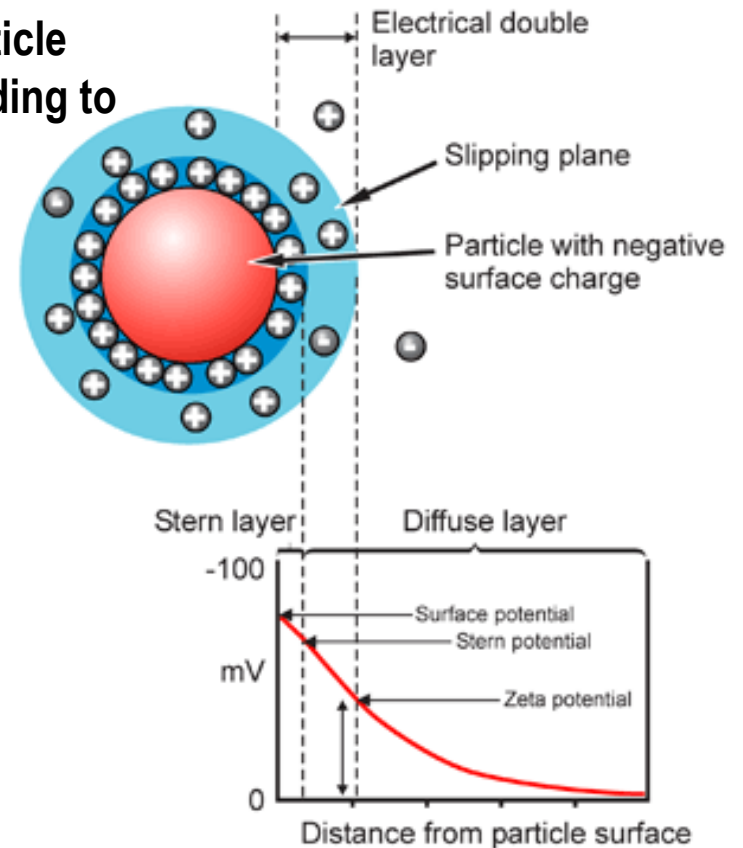
## Number-, Volume- and Intensity-Distribution

- Rayleigh Scattering:  $I \propto d^6$  and  $I \propto 1/\lambda^4$
- Volume of a sphere:  $4/3\pi(d/2)^3$



## Zeta Potential – Measurement of Charge

- **Zeta potential:** A potential exists between the particle surface and dispersing liquid which varies according to the distance from the particle surface.
- **Why do we use it:** determine whether the particle within a liquid will tend to flocculate or not.
- **Measurement:** with laser Doppler velocimetry and phase analysis light scattering (PALS)





## Common Terms Defined

- **Z-Average size or cumulants mean:** Harmonic intensity averaged particle diameter.
- **Polydispersity Index :** It is dimensionless and scaled such that values smaller than 0.05 are rarely seen other than with highly monodisperse standards. Values greater than 0.7 indicate that the sample has a very broad size distribution.
- **Correlation Curve – or correlation function**  
Measured data in a experiment is the correlation curve which should be a smooth, single exponential decay function for a mono-size particle dispersion.
- **Y-Intercept or Intercept :** Refers to the intersection of the correlation curve on the y-axis of the correlogram. The y-intercept can be used to evaluate the signal-to-noise ratio from a measured sample and thus is often used to judge data quality. It is usually scaled such that an ideal signal will give a value of 1, and a good system will give intercepts in excess of 0.6, and greater than 0.9 for the best systems.



## Common Terms Defined

**Count Rate or Photon Count Rate:** The number of photons detected and is usually stated in a “per second” basis.

