New Posts at the Course Website:

Origin Assignment 1 Answer Sheet.

Origin Assignment 2 on Dynamic Light Scattering (due 2/29/12)

- Problem Set
- Data (xls file)
- Background paper (P5) on the theory of the analysis method

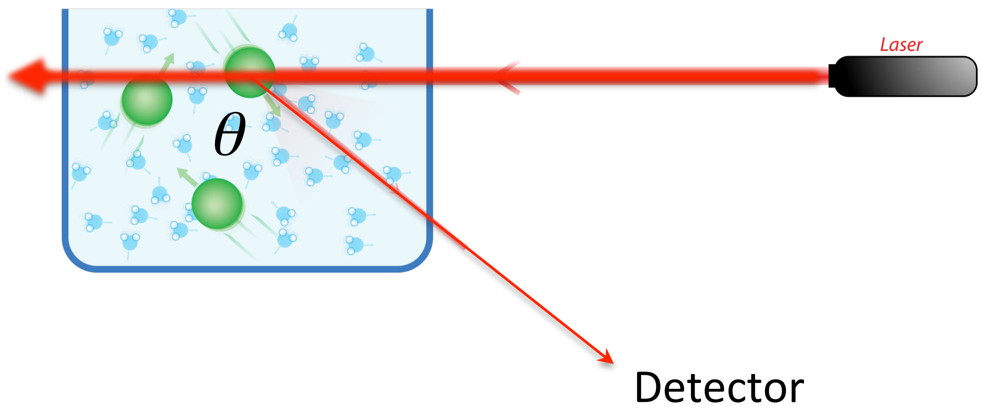
Dynamic Light Scattering

– measures fluctuations in light intensity *vs.* time

– light is scattered elastically by matter
  (Rayleigh scattering)

– correlation analysis of the fluctuations gives
  information of motion (diffusion coefficient)

The DLS experiment:



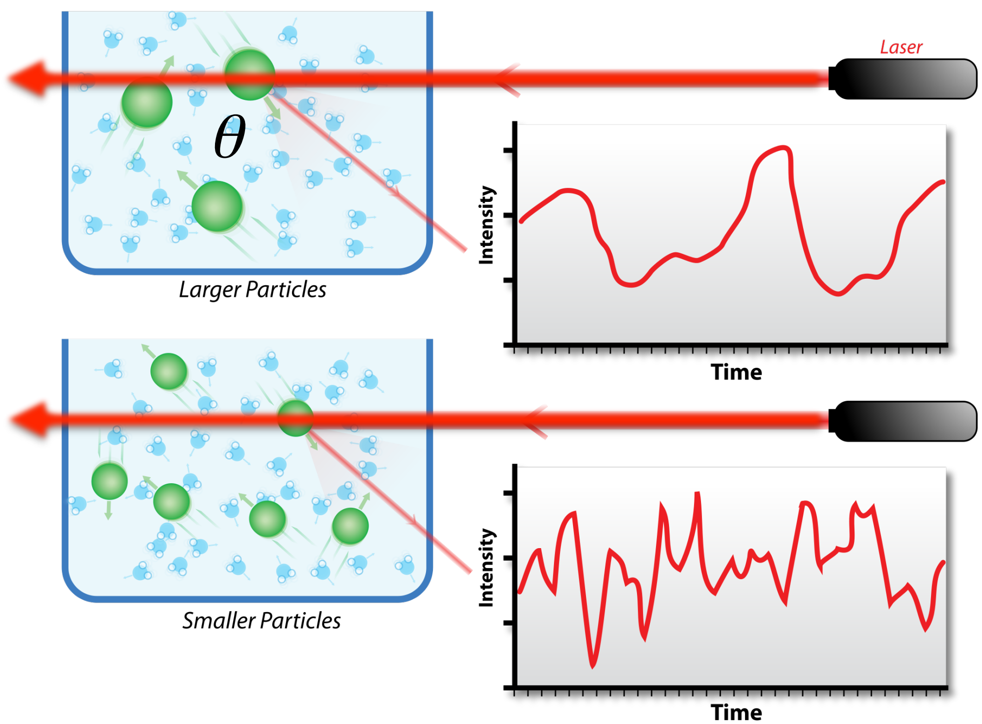
$$q = \frac{4\pi n_0}{\lambda}\sin\left(\frac{\theta}{2}\right)$$

q = scattering vector
θ = scattering angle
λ = wavelength of light
n_0 = refractive index

$$\Gamma = q^2 D_t$$

Γ = decay rate (reciprocal time)
D_t = translational diffusion coefficient

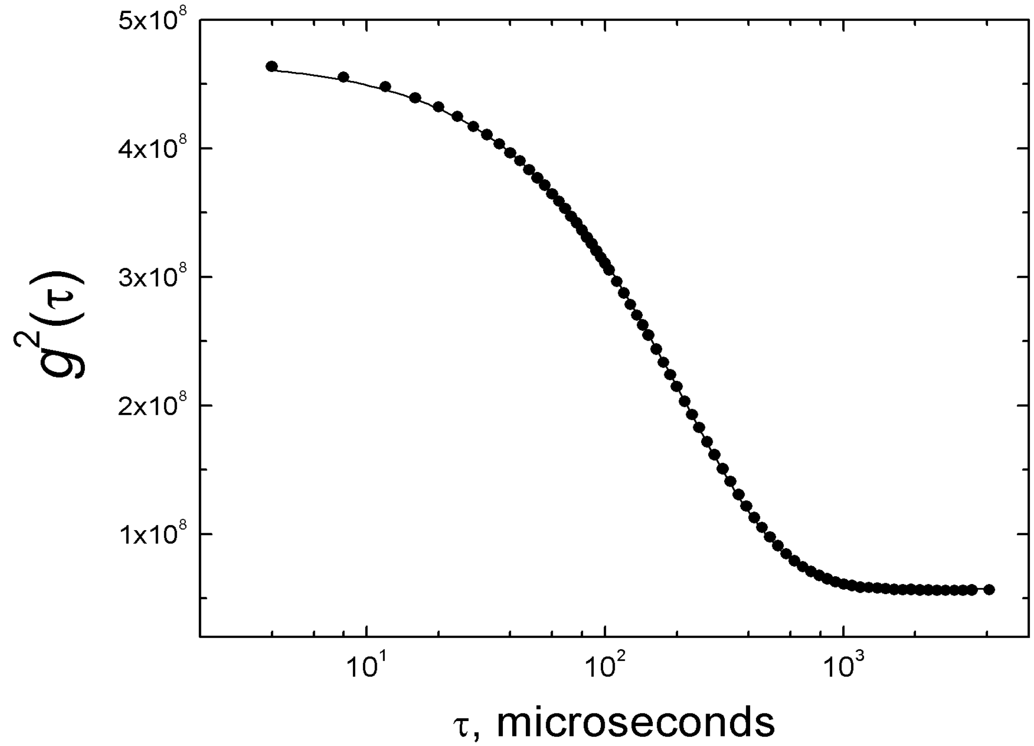
The DLS experiment performed on particles that differ in size. Notice that the fluctuations are more rapid in the sample with smaller particles.



$$g^2(q;\tau) = \frac{\langle I(t)I(t+\tau)\rangle}{\langle I(t)\rangle^2}$$

$g^2(q;\tau)$ the intensity (2^{nd} order) autocorrelation function is the observable (*i.e.* light intensities are detected, not amplitudes) that is analyzed to retrieve the decay rates.

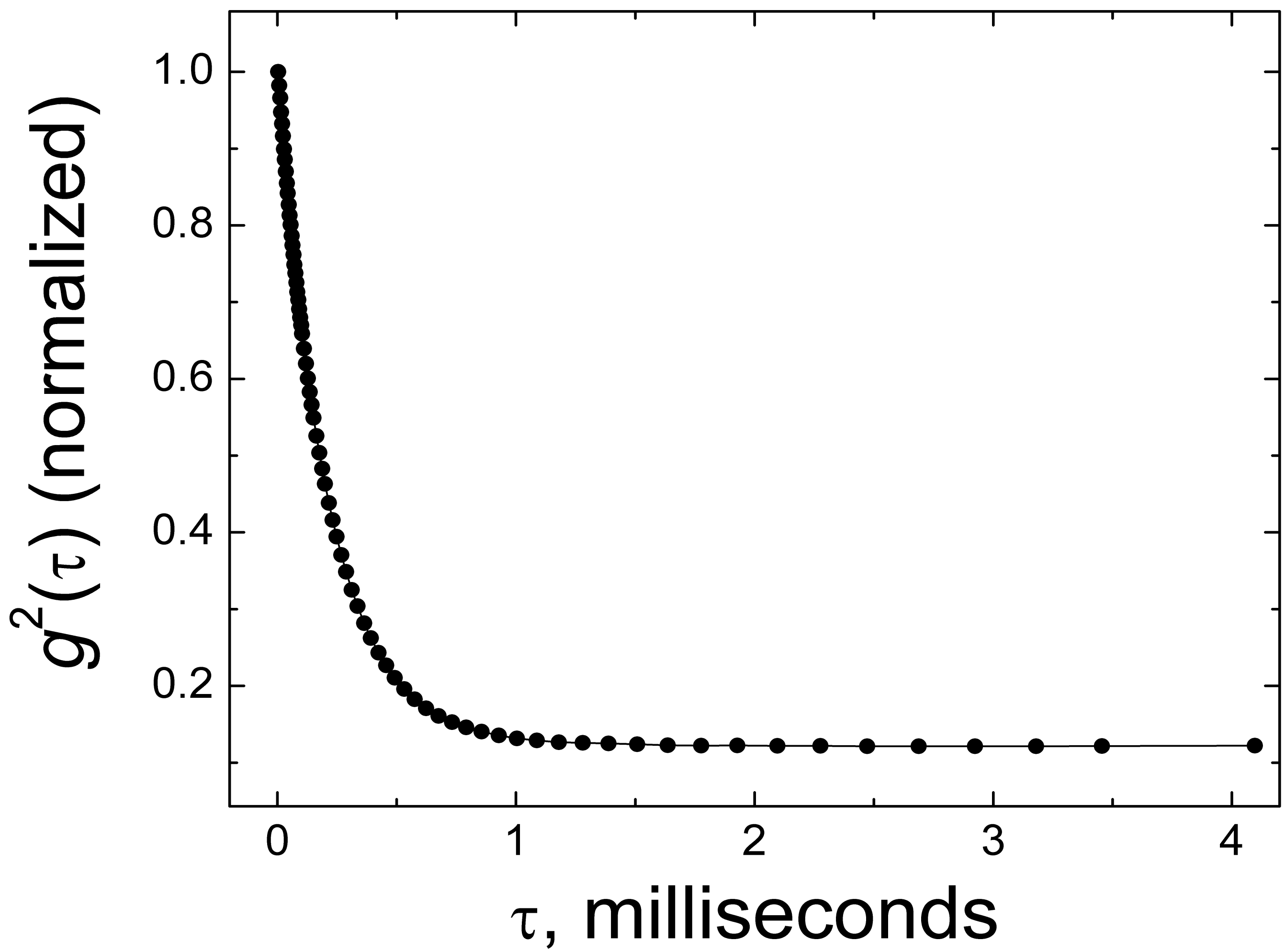
Intensity autocorrelation data, g^2(q,τ), plotted vs. log τ.
The decay is approximately exponential.



These data may not appear to decay exponentially; that is a result of the log scale on the τ axis, which expands the range for small values of τ.

Intensity autocorrelation data, $g^2(q,\tau)$, plotted vs. τ.

The decay is approximately exponential.



Models that describe the decay of the correlations are usually related to the *amplitude* autocorrelation function, $g^1(q,\tau)$, which is related to the intensity autocorrelation, $g^2(q,\tau)$ by the Siegert equation:

$$g^2(q,\tau) = 1 + \beta\left[g^1(q,\tau)\right]^2$$

where β is an instrument-specific constant.

If the sample is dilute (particles do not interact) and *monodisperse* (a single size), the autocorrelation function is modeled as a single exponential:

$$g^1(q,\tau) = \exp(-\Gamma\tau)$$

More generally, if the sample is *polydisperse*, the autocorrelation function can be modeled as a sum over the components, where the G_i are scattering amplitudes of the individual components that have Γ_i decay rates. If the distribution is continuous, this is modeled as an integral over the distribution of sizes and rates.

$$g^1(q,\tau) = \sum_{i=1}^{n} G_i \exp(-\Gamma_i\tau) = \int G_i \exp(-\Gamma_i\tau)$$

There are various ways to treat fluctuation (size) distributions depending on the complexity of the sample. If the sample is *polydisperse*, but *monomodal* (one peak in the distribution), the method of cumulants can be used (also called the method of moments). The first cumulant estimates the average of a Gaussian distribution (through Γ) and the second cumulant estimates the width of the distribution (through μ).

$$g^1(q,\tau) = \exp\left(-\Gamma\tau\right)\left(1 + (\mu/2)\tau^2\right)$$

The third and fourth cumulants (not shown) would provide estimates of the deviation (*skew* and *kurtosis*) from a normal Gaussian. By subsitution into the Siegert equation the 2nd order autocorrelation function becomes . .

$$g^2(q,\tau) = a + \beta\exp\left(-2\Gamma\tau\right)\left(1 + (\mu/2)\tau^2\right)^2$$