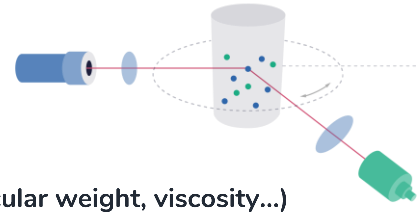
Advanced Light Scattering Techniques

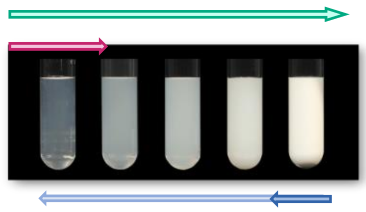
Dr. Coline Bretz, Dr. Ricardo Armenta, Dr. Andrea Vaccaro, Dario Leumann

LS Instruments AG, Fribourg, Switzerland

Why light scattering?

- ✓ Fast
- ✓ Low sample volume
- ✓ Easy sample preparation
- ✓ Nondestructive
- ✓ Powerful (measures size, shape, molecular weight, viscosity...)



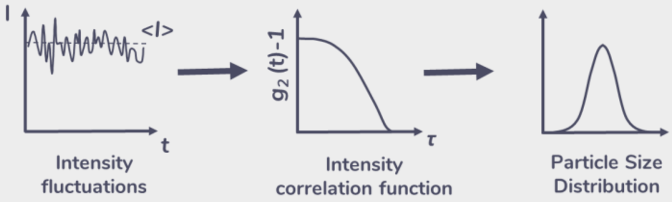


Reliable DLS Particle Sizing

Dynamic Light Scattering (DLS) provides a fast and in-situ means of measuring particle size. **It measures the diffusion of particles in a suspension.**

$$g(\tau) = e^{-Dq^2}$$

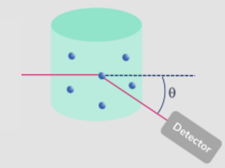
$$D = \frac{k_B T}{6\pi\eta R_h}$$



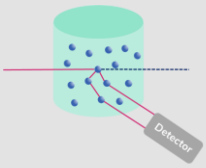
Challenge: multiple scattering in Standard DLS

The scattering signal often contains multiple scattering: this makes DLS measurements unreliable.

The theory of DLS assumes that only single scattering is taking place.



When multiple scattering is present, the measurements are unreliable



The traditional approach to minimize multiple scattering is to dilute the sample, but:

- » No access to the properties of the native system
- » When is it dilute enough?
- » Time consuming step

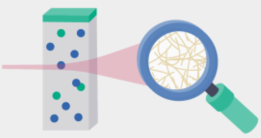
Solution: Modulated 3D DLS

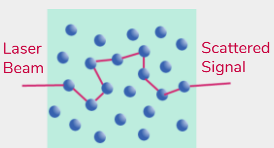
Two DLS experiments are performed simultaneously. By processing the two resulting signals, multiple light scattering is suppressed.

This technology filters out multiple scattering from the signal and removes undetectable and systematic errors in DLS measurements.

Contact-Free Rheology with DWS

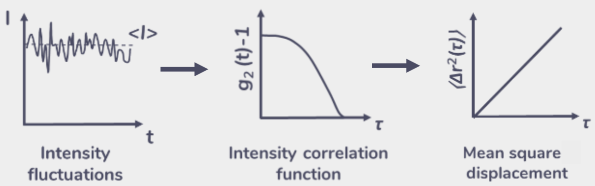
Diffusing Wave Spectroscopy (DWS) probes the motion of embedded “tracer” particles in a sample to obtain information on its relaxation dynamics. The Brownian motion of the tracer particles “probes” local deformation of the sample matrix. The deformation amplitude depends on the rheological properties of the local environment.





Particles can be either naturally present in the sample (particles in a suspension, droplets in an emulsion) or added to translucid samples.

DWS is based on the analysis of multiple scattering: photons perform a random walk within the sample.



With known particle size, rheological quantities can be extracted from the Mean Square Displacement

Microrheology

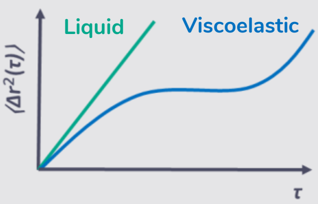
G’ , G”

$$G^*(\omega) = G'(\omega) + i\, G''(\omega) = \frac{k_B T}{\pi R_h i\omega\langle\Delta r^2(i\omega)\rangle}$$

The Mean Square Displacement

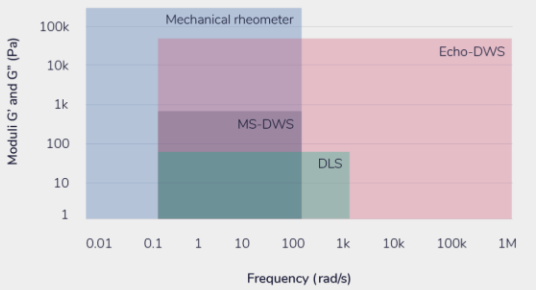
The Mean Square Displacement (MSD) is the average of the squared distance the tracer particles diffuse during the lag time τ. It provides information on the microstructure of the sample. Subtle changes can be detected by DWS.

In a Newtonian, liquid sample, particles are free to diffuse: the MSD is linear



Particles are inside a “cage” created by the interactions with the surrounding matrix.
These interactions give the elasticity to the sample and the MSD shows a non-linear behaviour.

DWS Microrheology enables access to a broad frequency range



References

Block & Scheffold, Modulated 3D cross-correlation light scattering: Improving turbid sample characterization, Rev. Sci. Instrum. 81, 123107 (2010).
Weitz & Pine, Diffusing-Wave Spectroscopy. In Dynamic Light Scattering; Brown, W., Ed.; Oxford University Press: New York, 652-720 (1993).

LS Instruments

Get in touch: info@lsinstruments.ch www.lsinstruments.ch +41 (0)26 508 54 98