

Where's my peak?

Dynamic light scattering vs. resistive pulse sensing

Dynamic light scattering (DLS) is a workhorse tool for the measurement of nanoparticles suspended in solution. It works by illuminating a sample with a laser, and monitoring the scattered light. As the particles move, due to Brownian motion, the scattered light changes in time, and this can be dynamically monitored and analyzed to extract the relative number and diameter of the particles in the suspension. DLS however suffers from two distinct drawbacks: First, DLS does not provide absolute concentration information, only relative information, and second, it has significant difficulties measuring broad, polydisperse solutions.

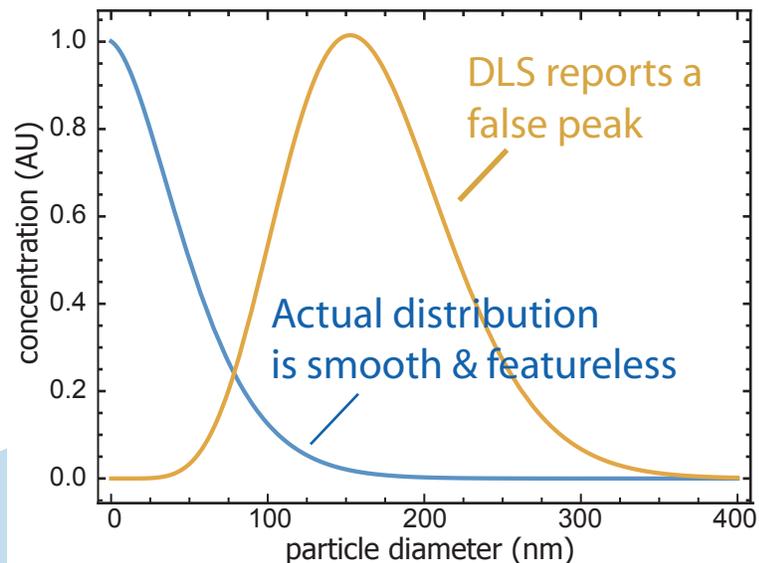
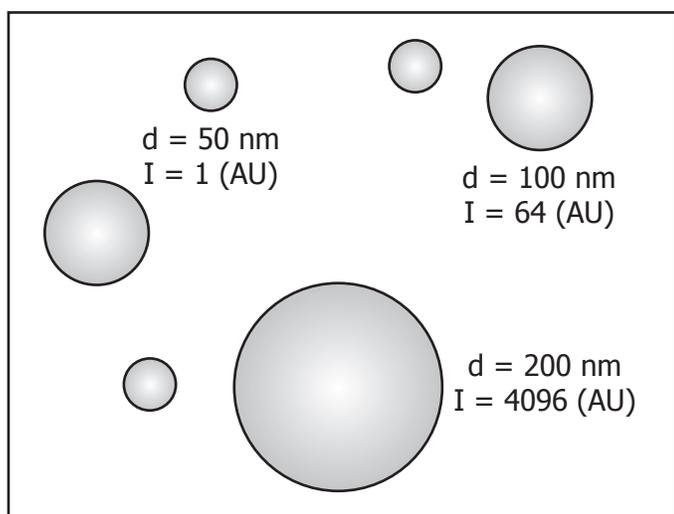
A common problem associated with DLS is that, when challenged with a polydisperse mixture of particles, it reports a peak in the distribution of particles when in fact no such peak is actually present.

The reason for this is due to how DLS works. For particles smaller than a few hundred nanometers, **Rayleigh scattering** determines the intensity of the scattered light that DLS detects. This intensity scales inversely with the laser wavelength to the fourth power, but more importantly, it scales with the particle diameter to the **sixth power**. This can be seen in the formula for the scattering cross-section below:

$$\sigma = \frac{2\pi^5 d^6}{3 \lambda^4} \left(\frac{n^2 - 1}{n^2 + 1} \right)^2$$

Here **n** is the particle's index of refraction. The scattered light intensity does not directly provide the diametric measurement; that is instead extracted from the time autocorrelation of the scattered light, due to the particles' Brownian motion, which with some assumptions allows extraction of the particles' hydrodynamic radii.

As a result of the diameter to the sixth power dependence, the light intensity scattered from larger particles is much higher than that from smaller particles. DLS can then miss the much dimmer small particles, and thus mis-report the relative abundance of small compared to large particles. This is illustrated schematically in the left figure below, which shows the relative scattering intensity **I** for three different particle diameters. The figure above shows how this can affect the measured particle distribution, where the blue curve shows the true particle distribution, and the orange curve shows what DLS might report, assuming that DLS over-reports larger particles in proportion to their scattering cross-section. This creates a false peak in the distribution, due to the increase of intensity with diameter, until the falling concentration of particles at larger diameters overwhelms this effect.



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Resistive pulse sensing (RPS), as employed in Spectradyne's unique microfluidics-based nCS1TM, by contrast detects and measures each individual particle by electronic means, avoiding the statistical challenges of DLS-style ensemble measurements. Every particle has equal weight in the statistical distribution, and RPS therefore reports the true distribution of particles. At Spectradyne, **every particle counts**TM.