Error-Free Dynamic & Static Light Scattering:
Principle & Applications of the Modulated 3D Technology

Webinar Q&A Transcript

1. **What is the minimum sample volume needed?**

In the NanoLab 3D the minimum sample volume needed is 4 µL. In the LS Spectrometer, it is 50 µL.

2. **How much deviation in results does one get for a given sample using the Modulated 3D technology vs Standard DLS?**

The difference between the two methods is the error caused by multiple scattering in Standard DLS. The onset of multiple scattering strongly depends on the sample properties: concentration, particle size, and refractive index play a role.

In the example of a suspension of polystyrene particles shown in the webinar, a significant error arises with standard DLS already from a volume fraction of 1 %. At a volume fraction of 10%, the error is more than 60%. The Modulated 3D technology, on the other hand, works error-free and the true particle size is obtained at any concentration. This system can be used as a model system, for example for viruses.

3. **What is the maximum volume fraction of particles that one can use?**

The maximum volume fraction is system-dependent (see the previous question). For example, in a suspension of polystyrene spheres as shown during the webinar, one can comfortably measure concentrations between 10% and 20% with the Modulated 3D technology. For particles with a lower scattering power (small proteins, low-density microgels) one can go to more than 40-50%.

4. **Is there an easy way to figure out what is the ideal concentration a sample should be measured at? And what parameters impact that?**

The ideal concentration range a sample should be measured is the one that provides an optimal count rate, typically 100-200 kHz and a high signal-to-noise ratio. In standard DLS, this often competes with the onset of multiple scattering.

With Modulated 3D DLS or SLS, there is no risk of signal-contamination by multiple scattering and thus one can obtain reliable results at any concentration. If the sample is extremely dilute, the scattering signal may be low. For this reason, LS Instruments manufactures devices with a minimum available laser power of 100 mW, the highest on the market.

We emphasize that a well-equipped DLS instrument does not restrict the user to a certain concentration range. Extremely dilute, to extremely concentrated samples can be characterized routinely with the NanoLab 3D and LS Spectrometer.

5. **Is it possible to measure in Modulated 3D and standard DLS on the same set-up?**

Yes. In both the NanoLab 3D and 3D LS Spectrometer, easy switching between the Standard DLS and the 3D or Modulated 3D correlation modes is a standard feature. However, if the Modulated 3D technology is available in your instrument, it should always be selected as the default measurement mode.

6. **It is possible to measure in auto- and cross-correlation mode at the same time?**

No. Auto- or Modulated 3D cross-correlation of the signal is done by the correlator and it is not possible to perform both operations at the same time. As in the previous question, if the Modulated 3D technology is available in your instrument, it should always be selected as the default measurement mode. There is no benefit in running parallel standard DLS measurements.

7. **Can the 'correction' impact the results obtained?**

No. When using the Modulated 3D technology, only the multiple scattering part is removed. The measured signal is exactly the same as in an ‘ideal’ DLS or SLS experiment,

8. **What limits the switching time of the modulator(s) to 800 ns?**

The maximum switching speed is imposed by the hardware and can be lowered by reducing the laser beam size as it reaches the acousto-optic modulator(s). While the switching time is 800 ns for the beam-split implementation in the 3D LS Spectrometer, it was reduced to 200 ns in the NanoLab 3D, in single beam implementation. 200 ns is well aligned with the fastest lag-time available in standard DLS instruments available on the market.

9. **Is it possible to make depolarized light scattering experiments combined with the Modulated 3D technology?**

Yes. For more details, please contact sales@lsinstruments.ch.

10. **I believe that adding an inclination of the incident beam adds internal reflections inside the cuvette. Do these reflections add errors to the measurements?**

The inclination does not affect reflections. The inclination creates two new scattering planes that operate independently and that are both are subject to the same reflections as the standard horizontal scattering plane. Actually, reflections are more dangerous when the beams reach the cell perpendicularly, for this reasons in standard DLS instruments cuvettes are normally slightly tilted.

11. **What about polydispersity? What is the best peak resolution that can be obtained?**

Typically a factor of two is the minimum size difference that can be resolved between two particle size peaks. However, this does not depend on whether we measured with the Modulated 3D technology, or in Standard DLS.

12. **How accurately can the Modulated 3D technology pick up polydispersity in samples?**

As in any DLS experiment, the accuracy of polydispersity depends on the measurement quality (dust is detrimental), the signal-to-noise ratio, and the fitting algorithm used.

For this specific topic, LS Instruments has developed CORENN, a novel advanced machine learning algorithm to extract the particle size distribution (PSD) from a DLS measurement. It leverages advanced signal approximation techniques and a unique theoretical estimate of the signal noise, yielding reliable results that are robust against experimental distortions. More information on the CORENN algorithm is available on our website.

13. **How difficult to align/operate the 3D LS Spectrometer? Does it require frequent service from LS Instrument?**

The alignment of the LS Spectrometer is done by LS Instruments at installation, and training is given for the operation of the instrument. Provided that the instrument is placed in an adequate environment (research laboratory) and is operated within guidelines, no frequent servicing is required.

14. **I'm interested to combine Modulated 3D DLS with small-angle neutron scattering (SANS). Do you think it is possible to do SANS and Modulated 3D DLS on the same sample volume? The incident neutron and photon beams could be at an angle close to 90 degrees.**

Measuring on the same sample volume would require a custom set-up. An easier implementation has been done previously by LS Instruments, whereby the sample chamber of the LS Spectrometer was slightly modified such that the sample cell protrudes out for the incident neutron beam. While the measurement was done on a different sample volume, this would not affect the results for a purely Brownian sample under proper temperature equilibration.

15. **When I want to move a 3D LS Spectrometer from a SANS instrument to another laboratory, would the alignment be lost, and would realignment by LS instruments be needed?**

This is likely, but can be avoided under proper moving conditions – the use of a vibration-free moving solution. However, such moving services are likely more expensive than a realignment by LS Instruments. We recommend referring to us to handle the moving of your 3D LS Spectrometer.