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Multi-angle Simultaneous Dynamic Light Scattering (MASDLS)

Polystyrene Particle Size Distribution Analysis at Five Simultaneous Scattering Angles

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Dynamic Light Scattering (DLS) is a technique used to determine the hydrodynamic size distribution of nanoparticles in solution, based on the temporal fluctuations in scattered intensity resulting from Brownian motion. The autocorrelation function (ACF) of the signal can be obtained at a specific angle(s), and therefore, the corresponding translational diffusion coefficient (D_T) in that direction, from which the hydrodynamic size of the particle distribution can be calculated.

Single-angle backscattering is well-suited for small, isotropic particles ($\leq$ 60 nm). For larger particles, anisotropic scattering, polydispersity, and aggregation can distort the ACF and introduce size bias if additional angles are not considered. Swabian Instruments' turnkey Dynamic Light Scattering system (DLS*cat*) can acquire multi-angle simultaneous DLS measurements (MASDLS) for more accurate particle size distribution analysis without compromising experimental acquisition speed.
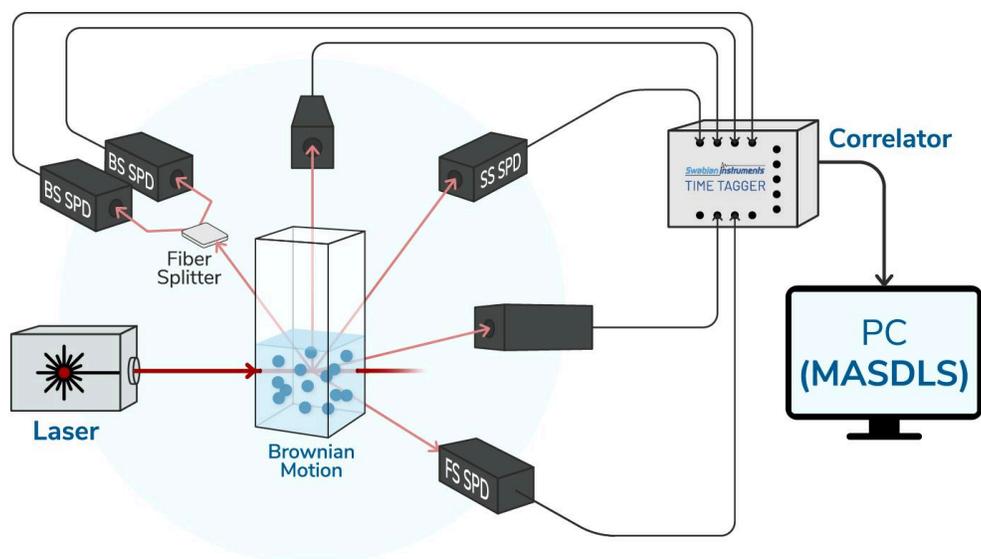

Fig. 1: Schematic of a multi-angle simultaneous DLS system: A laser illuminates a cuvette, scattered photons are detected by multiple single-photon detectors at the same time by a correlator (in this case, a Swabian Instruments' Time Tagger 20) for real-time analysis on a PC.

EXPERIMENTAL SETUP

Standard, nearly monodisperse (PDI $\approx$ 0.04) 100 nm radius polystyrene spheres dissolved 5% w/v in water (Microparticles GmbH, Germany) were used. 2 µL of sphere stock solution was dissolved in 5 mL of Milli-Q H_2O (Sigma-Aldrich, Germany). Measurements were conducted with 1 mL of diluted suspension in a polystyrene square cuvette with a 10 mm path length.

The sample was probed at geometric angles of 20°, 69°, 90°, 111°, and 157°. Due to the refractive index of water, the corresponding scattering angles were approximately 14.9° (forward), 74.4°, 90.0°, 105.6° (side), and 163.0° (backward). The scattered photons at each angle were detected and time-stamped by a multi-channel correlator (Swabian Instruments Time Tagger 20). The photon streams were processed in real-time software to obtain intensity

ACFs and decay rates Γ for each angle. From an analytical perspective, DLScat software can calculate Cumulants and CONTIN fits. Generally, Cumulants fit is better for monomodal, low-polydispersity samples (PDI < 0.20), while CONTIN is more suitable for highly polydisperse or multimodal populations [1].

RESULTS

Each single-angle particle size distribution (Figure 1a) reported a narrow main population close to the nominal 200 nm diameter size, while the apparent hydrodynamic radius varied systematically with angle.

For a more accurate size determination, the decay rate Γ from multiple angles was plotted against the scattering vector q² (Figure 1b). The slope of the linear fitting yielded the DT. Using the Stokes-Einstein equation and considering that temperature and water viscosity were known, the hydrodynamic radius RH was obtained from DT, resulting in a measured RH = 103.9 nm. The software performed this analysis using both Cumulant and CONTIN fits.
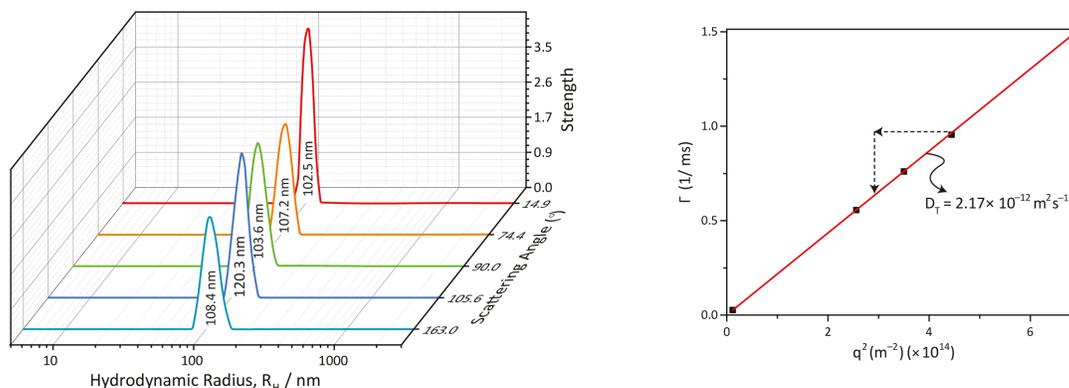

Fig. 2: (Left) Particle size distribution of 200 nm diameter polystyrene spheres at multiple scattering angles. (Right) Calculation of the translational diffusion coefficient (DT) from fitting all the Γ vs q² at different angles.

CONCLUSION

Here, we used DLS*cat* to measure polystyrene spheres using a simultaneous multi-angle DLS method, where decay rates from five scattering angles were combined in a Γ vs q² analysis to obtain an angle-independent diffusion coefficient, DT, and the corresponding hydrodynamic radius, RH.

When decay rates from all scattering angles were combined in a single Γ−q² fit, RH = 103.9 nm was obtained. The angle dependence observed in the individual single-angle results (Figure 2a) indicated how non-isotropic scattering and small deviations from ideal monodispersity can influence DLS sizing for larger particles. In contrast, the combined analysis provides a more robust size estimate and an internal check on data quality.

This work highlighted the importance of multi-angle simultaneous dynamic light scattering (MASDLS) experiments in obtaining a more accurate measurement of the particle size distribution under evaluation.

REFERENCES

[1] https://www.swabianinstruments.com/dls-cat/ *(Online. Accessed Dec 16th, 2025)*

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