Science is our passion and when it comes to light scattering, we make no compromises. Our mission is to provide you with the most reliable and precise equipment possible.

Innovative design, only the best components, transparent data processing without any secret fudge factors, full access to the unbiased raw data, and support by our team of experts enable our customers to rapidly advance and obtain rock solid results.
DLS is the technology of choice to measure the size of nanoparticles in solution. Driven by Brownian motion, the particles move within the solvent, causing the intensity of scattered light to fluctuate. Since the size of the particles influences the motion and thus the statistics of the fluctuations, the diffusion coefficient and particle size are obtained from the intensity correlation function. Unlike most DLS instruments, the LS Spectrometer can do this for a wide range of scattering angles (8° to 155°), therefore, significantly increasing the precision of your measurements.

STATIC LIGHT SCATTERING (SLS)

SLS measures the scattered intensity in dependence of the scattering angle, \( \theta \). The LS Spectrometer has an angular resolution of 0.01° and thus enables precise measurement of form and structure factors, radius of gyration, molecular weight, virial coefficient and much more. In this manner you gain information not only on the size, but also the shape, density and structure of your sample. The additional synergy resulting from the combination of SLS and DLS in the LS Spectrometer makes it the perfect tool for sophisticated research.
No other instrument measures form and structure factor with a higher precision than the LS Spectrometer. The powerful detectors can be rotated precisely to any selected scattering angle. Unlike Multi Angle Light Scattering (MALS) systems that can only measure the intensity at a limited number of scattering angles, you will never miss a peak with the LS Spectrometer! Furthermore MALS systems are typically not equipped to perform DLS at different scattering angles.

While most DLS instruments only measure at a limited number of fixed scattering angles, the LS Spectrometer can obtain precise DLS data at any angle within its vast angular range (8°–155°). This is important, because the particle size determined by a DLS experiment is based on the assumption that the particles are monodisperse hard spheres. Whenever this is not strictly true, the measured particle size is only an apparent size that is often dependent on the scattering angle. For unknown particles it is therefore important to confirm angular dependence and if necessary apply corrections that can be based on complementary SLS measurements. If measured at only 90° or 173°, which are typical angles employed by fixed angle instruments, the measured apparent size for certain samples can be two times smaller/larger than the actual size*.

Both DLS and SLS technologies are based on the assumption that only single scattered light is detected. As particle concentration increases however, multiple scattering increases and gradually dominates the signal. This introduces an undetectable systematic error in both DLS and SLS. No matter how long or how many times you repeat the measurement, you can’t remove or detect this error. To overcome this issue, LS Instruments has developed the optional 3D cross-correlation module that efficiently suppresses multiple scattering.

The 3D cross-correlation technique uses two laser beams to perform two scattering experiments simultaneously. While the contribution originating from the single scattering is identical, the multiple scattering contribution is different in the two experiments. By cross correlating the signal, multiple scattering is thus suppressed. The 3D LS Spectrometer is the only instrument that offers 3D cross-correlation for both DLS and SLS, providing unique data for many outstanding publications.
SAMPLE GONIOMETER

Many samples suitable for light scattering show a non-ergodic behavior that results in measurement errors. LS Instruments has developed a sample goniometer that rotates non-ergodic samples at a suitable speed to obtain the correct results. Moreover, the sample goniometer can also be used to displace the sample from the center of rotation. This enables the use of square cells in which the path of the scattered light in the sample can be reduced to less than 200 micron, which significantly reduces multiple scattering.

LASER SYSTEMS

The LS Spectrometer can be equipped with a high performance Laser, selectable from a range of different wavelengths (457 nm to 1064 nm) and intensities (20 mW to 500 mW). We are proud to offer a selection of Lasers manufactured by Cobolt, the leader for innovative Laser technologies. Cobolt Lasers are based on the unique and proprietary HTCure™ technology yielding unrivaled robustness and reliability. Specialized Laser technology was developed by Cobolt for LS Instruments within a European research project to optimize performance for light scattering.
**SOFTWARE**

LS Instruments leverages on the latest programming techniques to provide software that is state of the art, such as the powerful open source cross platform programming environment .NET. We can thus rapidly adapt to the ever changing digital world, while also continuously improving features and performance. The standard software includes real-time CONTIN and Cumulant analysis as well as a wizard to program series of measurements with changing measurement parameters. Powerful supplementary software to conduct post-processing of SLS data is provided with the LS Spectrometer.

**SYSTEMS**

- Nanoparticles
- Polymers
- Peptides
- Proteins
- Emulsions
- Micelles

**INDUSTRIES**

- Pharmaceuticals
- Dairy products
- Cosmetics
- Paints

**PROCESS MONITORING**

- Gelation
- Aggregation
- Ageing
- Micelle formation
- Protein denaturation

The Zimm Plot tool of LS Instruments is unmatched in both performance and ease-of-use.
## Specifications LS Spectrometer

<table>
<thead>
<tr>
<th>Technology</th>
<th>Dynamic and Static Light Scattering (DLS and SLS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scattering angle</td>
<td>8° to 155° +/- 0.01°</td>
</tr>
<tr>
<td>Hydrodynamic radius</td>
<td>0.15 nm to 5 µm*</td>
</tr>
<tr>
<td>Radius of gyration</td>
<td>5 nm to 5 µm*</td>
</tr>
<tr>
<td>Molecular weight</td>
<td>360 - 3,600,000 Dalton*</td>
</tr>
<tr>
<td>Correlator</td>
<td>320 channels, delay time 12.5 ns to 15 h, auto- and cross-correlation</td>
</tr>
<tr>
<td>Detectors</td>
<td>Two high performance APDs, QE 65%, dark counts &lt; 250 count/s</td>
</tr>
<tr>
<td>Laser wavelength</td>
<td>Wide range of choices: 457 to 685 nm</td>
</tr>
<tr>
<td>Laser power</td>
<td>Wide range of choices: 20 to 500 mW</td>
</tr>
<tr>
<td>Laser control</td>
<td>Fully automated active Laser intensity optimization</td>
</tr>
<tr>
<td>Detection</td>
<td>Single mode fiber detection system with integrated collimation optics</td>
</tr>
<tr>
<td>Sample cells</td>
<td>Fits 5 and 10 mm diameter cylindrical cells (min sample volume 50 µl)</td>
</tr>
<tr>
<td>Software</td>
<td>Including Cumulant, CONTIN and Zimm Plot analysis</td>
</tr>
<tr>
<td>Modular system</td>
<td>Wide range of optional modules</td>
</tr>
</tbody>
</table>

* As for all DLS instruments, the maximum range is sample dependent.
The LS Spectrometer by LS Instruments is the most sophisticated light scattering system for both static and dynamic light scattering (DLS & SLS) available. The modular design of the Spectrometer allows easy replacement of individual parts making it a unique instruments suited for your specific requirements, without compromising neither precision nor quality. Ask the experts at LS Instruments to configure the optimal solution for your laboratory.

Standard applications include:

- Particle sizing
  - Hydrodynamic Radius: 0.15 nm – 5 micron*
  - Radius of Gyration: 5 nm – 5 micron*
- Measurement of size distribution, polydispersity
- Diffusion coefficient, mean square displacement
- Molecular weight determination: 360 - 3600000 Dalton*
- Determination of 2nd virial coefficient
- Rayleigh ratio
- Determination of form and structure factor
- Inter particle distance in charged systems
- Process monitoring (e.g. gelation, aggregation, ageing...)

* maximum range, sample dependent
Specifications LS Spectrometer v1.04

- The LS Spectrometer performs both static (SLS) and dynamic light scattering (DLS) experiments at all scattering angles from 8° to 155° with a resolution better than 0.01°.
- Two supplied cuvette holders allow measurements with cylindrical scattering cells of two different diameters (10 mm and 5 mm nominal outer diameters). Use of the 5 mm cylindrical cell reduces required sample volume to about 50 μL.
- Temperature controllable sample chamber with index matching vat for measurements in the suggested temperature range from -5°C to 90°C (requires external circulator for temperature Control, see options). Temperatures at or below the dew point (approximately 15 °C, but dependent upon relative humidity of environment) require dry air or nitrogen in order to avoid condensation. Neither a dry air nor a nitrogen source are provided. Please contact LS Instruments if you have special temperature requirements.
- Direct on-line temperature measurement in the index matching vat via a PT-100 temperature sensor. The vat has a anti-reflection coating to minimize scattering from reflections.
- Pseudo cross-correlation technology: All photon detectors have a certain probability to produce a second electronic pulse after they detect a photon (the so called "after-pulsing-effect"), this results in significant errors for lag times lower than 1 μs. Since the LS Spectrometer is equipped with two detectors that are assembled in pseudo cross-correlation mode it automatically eliminates the after-pulsing-effect, thus allowing measurements down to 25 ns lag time which is required typically for small or fast diffusing particles.
- The two high sensitivity APD detectors of the LS Spectrometer allow measurement of samples with very weak scattering: quantum efficiency 65% at 633 nm, dark count < 250 count/s
- Single mode fiber detection system with integrated collimation optics.
- Two channel multi-tau correlator: auto and cross correlation, 12.5 ns minimum sampling time, 322 channels for multi-tau and more than 1000 channels for linear correlation, delay time range: 12.5 ns to 54976 s in multi-tau
- Laser not included (see options)
- Laser safety measures include an enclosed laser beam guide unit and beam shutter.
- Automated laser attenuation system combined with on-line laser intensity measurement. The Laser is automatically set to ideal measurement intensity. Manual setting is not required. This includes an automated safety control of the sensitive APD detector, such that it is only active under safe illumination conditions. Laser intensity can be recorded by the software for later normalization of the static light scattering data.
- 2.5 cm (1") diameter holders allow use of any standard optical filter in front of the detectors.
- PC (Windows) with flat screen (22") and preinstalled software
- Software (supplied) controls the spectrometer to acquire data for static and dynamic light scattering experiments. The standard software includes Cumulant and CONTIN Analyses for particle sizing as well as the LSI Zimm Plot analysis package. One free upgrade of the standard software will be provided free of charge within the first year after installation. Optional software packages (not included) are available to perform advanced analysis of dynamic and static light scattering data.
- Detailed manual
- The LS Spectrometer is delivered with and mounted on an aluminum bread board of 90 x 45 cm size. An optical table is not required for the standard configuration.
- The LS Spectrometer is a precision optical instrument that requires a laboratory environment for optimum operation. No more than 60% relative humidity, temperature range 17°-26°C, temperature stability +/- 1°C within 1 h and +/- 2°C within 24 h.
Suggested Optional Items

3D Cross-Correlation

DLS and SLS experiments are based on the assumption that only singly scattered light is detected. Already a small amount of multiple scattering can result in significant errors. This is why DLS and SLS frequently require dilution of the sample to avoid multiple scattering. With the 3D cross-correlation option multiple light scattering is suppressed efficiently, thus allowing measurements of many samples in their natural undisturbed state, without any need for dilution. Two simultaneous light scattering experiments are performed at the same scattering vector on the same sample volume in order to extract only the single scattering information common to both. This option also eliminates the after-pulsing-effect just as the pseudo cross-correlation.

Note: the minimum scattering angle is increased to 12° when using the 3D cross-correlation option. Obtained intercept is > 17%.

3D cross-correlation technology: Instead of using only one beam, two beams are used to probe the sample. Cross-correlation of the two signals suppresses the contribution of multiple scattering.
Modulated 3D

Although the 3D cross-correlation technique offers significant advantages to regular DLS and SLS, it also comes with a drawback. Because of cross-talk between the two detectors the maximal intercept is decreased from 1 to 0.25, effectively reducing the signal to noise ratio. The 3D modulation option eliminates this disadvantage. The two scattering experiments are temporally separated by modulating the incident laser beams and gating the detector outputs at frequencies exceeding the timescale of the system dynamics. This robust modulation scheme eliminates cross-talk between the two beam-detector pairs and leads to a four-fold improvement in the cross-correlation intercept.

By modulating the two illumination beams and synchronizing this with a modulation of the photon detectors, the signal to noise ratio can be improved significantly.

The modulated 3D cross-correlation mode is computer-selectable such that the standard 3D cross-correlation, pseudo-cross-correlation, and auto-correlation abilities are present and unaffected (>95% transmission through modulation unit). Note: for Modulated 3D, the minimum available lag time is user selectable: 800 ns, 1600 ns or 3200 ns. Obtained intercept is >65%.

The 3D cross-correlation technology significantly extends the range of accessible sample concentrations. The range is extended even further with the modulation technology while also improving the measurement quality significantly.
Sample Goniometer

Sample goniometer for measurement of non-ergodic systems (e.g. gels, glasses, foams) by continuous rotation of the sample. Additionally this allows for DLS and SLS experiments with extremely turbid samples in square cells using the so-called $\Theta-2\Theta$ detection, where the optical path length in the sample can be adjusted and significantly reduced (as low as 0.2 mm).

The main and sample cell goniometer can be controlled separately via the spectrometer control software. The optical path length in the sample is adjustable when rectangular cells are used.

External Circulator for Temperature Control:

Julabo CF31

Constant temperature bath from -30° to 200°C with a temperature stability of +/- 0.02°C. This powerful circulator perfectly suited for the LS Spectrometer. It reduces heating and cooling time significantly compared to other circulators. It can be pre-programmed to conduct measurement series at different temperatures with the software module of LS Instruments.

Included: Temperature bath and circulator, setup, calibration, software module for the LS Spectrometer

Notes: The suggested temperature range of the instrument itself (-5° to 90°C) is not increased with this circulator.
Laser Options

LS Instruments can provide high quality Lasers at a wide range of different wavelengths and intensities that are suitable for the LS Spectrometer: 457 nm, 491 nm, 532 nm, 561 nm, 633 nm or 660 nm. Please contact LS Instruments for quotes on specific wavelength and Laser intensities. All lasers include a special mount with heat sink suitable for assembly with the LS Spectrometer. For standard applications we suggest a HeNe Laser with 21 mW:

**HeNe Laser 21 mW**
Description: 632.8 nm, TEM00, noise < 0.5% rms, Laser class 3B.

Some samples only scatter light very weakly. In this case a HeNe Laser will not provide sufficient intensity for a good signal. This is specifically the case, whenever the Laser intensity is further reduced by optional items or upgrades such as the 3D cross-correlation module or the correlation mode switch. Furthermore, even HeNe Lasers of the highest quality show long-term fluctuations that can affect SLS and DLS results, if the measurement duration is longer than 10 minutes. HeNe Lasers are also sensitive to temperature changes. For optimal operation of the LS Spectrometer we suggest following lasers:

**High Performance DPSS Laser 660 nm, 100 mW, 300 mW, 500 mW**
Description: 660 nm, TEM00, coherence length > 10m, noise < 0.1% rms, Laser class 3B.

**High Performance DPSS Laser 532 nm, 100 mW, 300 mW, 500 mW**
Description: 532 nm, TEM00, coherence length > 10m, noise < 0.1% rms, Laser class 3B.

**High Performance DPL Laser 561 nm, 100 mW**
Description: 561 nm, TEM00, coherence length > 1m, noise < 0.1% rms, Laser class 3B.

*All DPSS and DPL Lasers provided by LS Instruments offer a longer life time, coherence length, robustness, lower sensitivity to temperature changes than HeNe Lasers, and are equipped with an optical isolator to ensure immunity to feedback. Furthermore for DPSS Lasers full or reduced power can be selected from within the software. Laser power stability is monitored by the software to ensure reliable measurements.*

Laser Enclosure System

Depending on the equipped Laser and the laser safety standards of your laboratory, it might be necessary to enclose the LS Spectrometer with a laser protection system to fulfill the highest safety requirements possible. For this purpose, we offer a suitable enclosure that can be mounted on an optical table (160 x 90 cm, please contact us for custom sized solutions).

The enclosure consists of a metal frame that supports a retractable laser curtain, certified according to EN 60825-4 (Laser Guards).