Suppression of Multiple Scattering

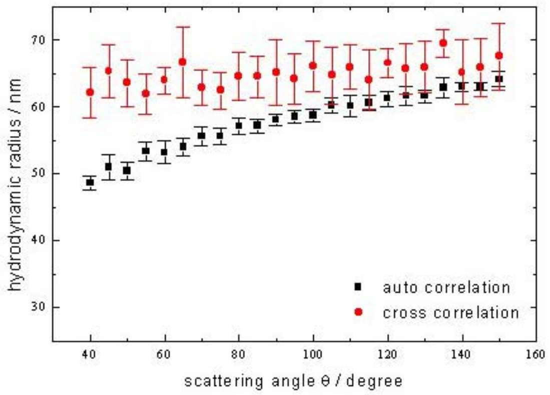

Figure 1: Hydrodynamic radius of a concentrated (c=0.1 wt.%) aqueous suspension of latex particles (66 nm, REM) determined by conventional dynamic light scattering (squares) and the one-beam cross correlation technique (circles)

Dynamic and static light scattering experiments are important tools for the investigation and characterization of structural and dynamic properties of polymer solutions, colloidal suspensions or more general multi-component systems. However, the analysis of these experiments is restricted to low concentrations in order to avoid multiple scattering.

Several theories which incorporate multiple scattering have been proposed. This rather complex task requires the knowledge of experimental details which are often not known with the required precision.

A more successful way was the development of new optical methods to suppress the influence of multiple scattered light experimentally. Different techniques have been proposed and successfully applied. In our group we use the so-called one-beam cross correlation experiment which is based on the fact that singly scattered light results in a larger coherence area than multiple scattered light. By placing two detectors at the edge of the coherence area and cross correlating the signals only singly scattered light is correlated, while multiply scattered light due to its smaller coherence area is no longer correlated.

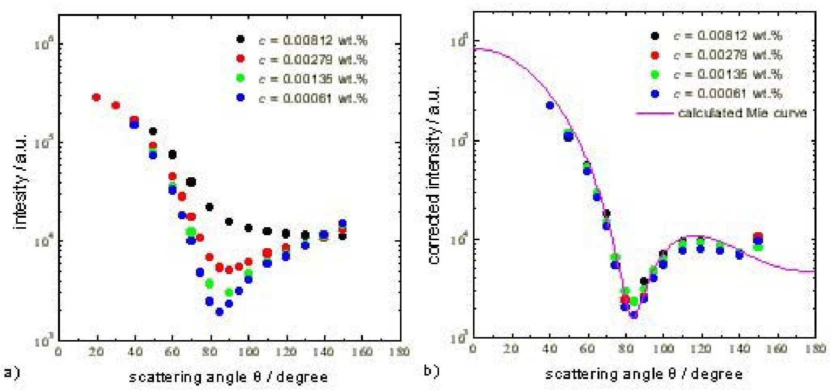

Figure 2: a) Scattered intensity of an aqueous suspension of 453 nm latex particles at different concentrations showing the effect of multiple scattering. b) The same scattered intensity multiplied by the amplitude of the cross correlation function leads to the correct differential cross section.

This technique allows the correct determination of the hydrodynamic radius also of turbid samples. In this case a conventional dynamic light scattering experiment (auto correlation) yields values that are too small.

This method not only gives the correct dynamic scattering properties, but also reveals the correct static information. The analysis of the amplitude of the cross correlation function permits the determination of the differential cross section even for highly turbid suspensions. This could be demonstrated for spherical latex particles with a diameter of 453 nm.

The one-beam cross correlation technique can also be used in depolarized scattering experiments. Due to the low depolarized scattering intensities, multiple scattering is as disturbing as in the case of Mie-scatters in the vicinity of the minimum of the formfactor function in these experiments. As model systems we used fluorinated polymer colloids with a spherical shape and internal crystalline

structure (MFA). We demonstrated that even in the case of highly concentrated suspension the correct particle diameter can be obtained.
This development in light scattering techniques for turbid samples helps to close the concentration gap between light scattering and x-ray scattering studies.

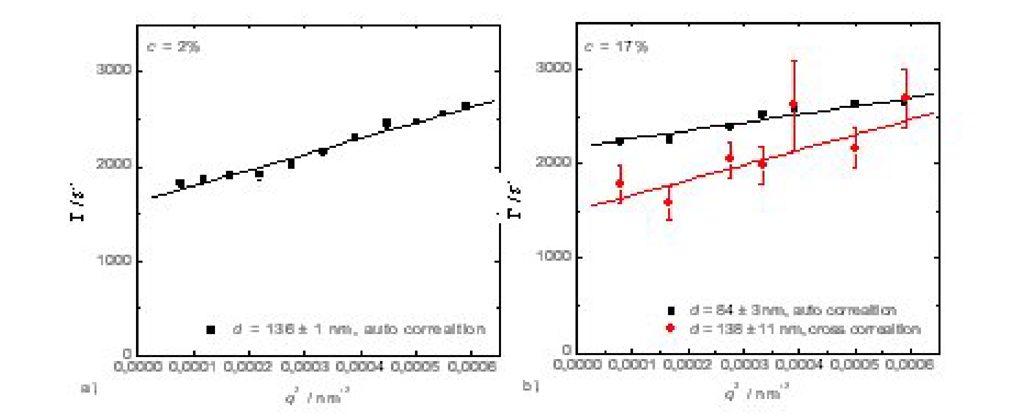

Figure 3: a) Decay rate for a dilute solution (c=2 wt.%) of MFA particles plotted against the square of the scattering vector. A particle diameter of 136 nm is found. b) The same plot for a highly concentrated sample (c=17 wt.%) shows, that the auto correlation function yields a diameter of 84 nm, while the cross correlation function results in the correct value of 138 nm.

References:

[1] J.-M. Schröder and S. Wiegand, Suppression of multiple scattering in a depolarized light scattering experiment using the one-beam set-up, Soft Materials, 1(2003), p.55-63

[2] J.-M. Schröder and S. Wiegand, Experimental suppression of multiple scattering: Effect on dynamic and static scattering data, Physical Chemistry Chemical Physics 2 (2000) 1493-1495.

[3] J.-M. Schröder, S. Wiegand, L.B. Aberle, M. Kleemeier and W. Schröer, Experimental determination of singly scattered light close to the critical point in a polystyrene-cyclohexane mixture, Physical Chemistry Chemical Physics 1 (1999) 3287-3292.