![ESRF logo] **ESRF**	**Experiment title:** Hydrodynamic interactions in concentrated, charge-stabilized colloidal suspensions	**Experiment number**: SC-2325
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Report:

Colloidal systems acting as a model system for condensed matter have been thoroughly studied during the last years. While the observed particle interactions in the case of a hard-sphere system are well explained by theory, this is not the case for indirect particle interactions between charge-stabilized colloids. Therefore we studied the direct and indirect particle interactions of a novel synthesized charge-stabilized system – a copolymer of a fluoro- and a silyl-methacrylate.

We measured two different sample-sets with different mean particle diameters of this new polymer-particles. The system showed no signs of beam damage even after being subjected to X-ray-radiation for some hours, allowing us thereby the usage of a focused beam. The photon flux on the sample behind a 10μm pinhole was 7×10^9 photons/sec@185mA.

In a charge-stabilized colloidal system the direct interaction between two particles can be described by a screened Coulomb ("Yukawa") potential $V(r) = e^2 z^2 (4\pi\varepsilon_0\varepsilon_r r)^{-1} \exp(\kappa r)$ where z is the effective number of charges per macro-ion, ε_0 is the vacuum dielectric constant and ε_r the relative dielectric permittivity of the solvent and r is the inter-particle distance. κ is the inverse Debye screening length with $\kappa = e^2 (k_B T\varepsilon_0\varepsilon_r)^{-1}(nz+2c_s)$, where n is the number density of the macro-ions and c_s is the amount of added electrolyte. Changing of the direct interaction strength is therefore possible by either varying the concentration of electrolyte or by changing the particle volume fraction Φ, and we prepared series of different volume fractions and different electrolyte concentrations.

Investigating a sample with a fully screened interaction pair potential we measured the effective diffusion coefficient D(Q) at different wave-vectors using XPCS. In this case D(Q) is equal to the Stokes-Einstein diffusion coefficient $D_0 = k_B T(6\pi\eta R)^{-1}$ and it is possible to deduce the hydrodynamic radius. The result (135±7 nm and 57±2 nm respectively) is in good agreement with the hydrodynamic radius obtained by dynamic light scattering experiments (135±1 nm and 57±1 nm), as shown in figure 1A. Fitting the particle form factor obtained by a static scattering experiment (SAXS) also evaluates a comparable particle radius of 134±1 nm and 54±1 nm, respectively (see figure 1B).
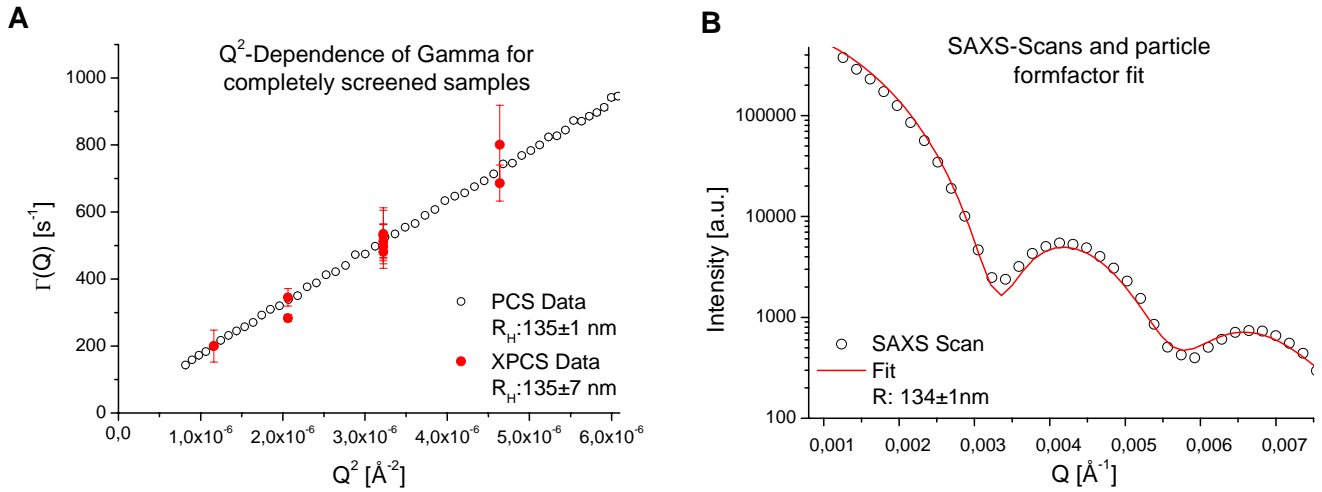
Fig. 1: A: Linear Q^2-Dependence of the relaxation rates $\Gamma(Q)$ of two completely screened samples, measured with PCS and XPCS, respectively. PCS on a highly diluted sample (Φ: 25×10^{-4}, c_{salt}: 2×10^{-4} mol/l) yields a hydrodynamic radius R_H: 135 ± 1 nm and XPCS (Φ: 0.01, c_{salt}: 2×10^{-4} mol/l) gives a R_H: 135 ± 7 nm. B: Small Angle X-ray Scattering scan of the same sample as measured with XPCS results in a particle radius of 134 ± 1 nm.

The investigated volume fractions were between 0.01 and 0.2 and the investigated electrolyte concentrations ranged from 0 to 1000 µmol/l potassium chloride. For each sample static data were taken by a SAXS experiment, the static structure factor was subsequently extracted. Afterwards XPCS was used to measure the effective diffusion coefficient D(Q) at different wave-vectors. The corresponding correlation-functions $g_2(t)$ show two different time regimes – a short time diffusion coefficient and a long time diffusion coefficient can be deduced from the data. An example is shown in figure 2. By merging the results of the SAXS and XPCS experiments we can extract the corresponding hydrodynamic functions of each sample: $H(Q) = D(Q)S(Q)D_0^{-1}$.

Data analysis is ongoing – the quality of the data appears to be good and we expect to extract the desired information on the hydrodynamics as a function of volume-concentration and electrolyte-concentration.
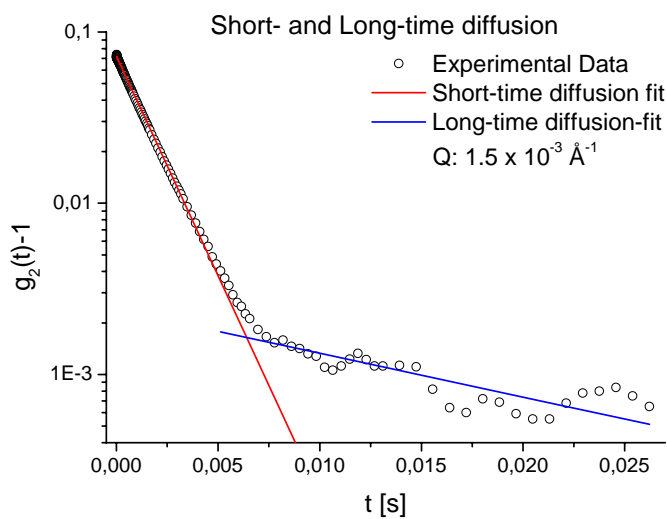

Fig. 2: Intermediate scattering function of a particle suspension with $\Phi = 0.12$, $c_{salt} = 2 \times 10^{-4}$ mol/l, $R = 134$ nm at $Q = 1.5 \times 10^{-3}$ $Å^{-1}$. The fits to the data indicate a short-time (red line) and a long-time (blue line) diffusion.