Chapter 7

Performances of ONFS and ENFS on two colloidal samples.

In this chapter we describe ONFS and ENFS measurements we made on two colloids and discuss the results. The optical setup has already been described in Sections 4.7.

7.1 The samples.

The samples we used are monodisperse colloids made of polystyrene spheres suspended in water. In order to avoid sedimentation, we used a mixture of water and heavy water with a weigh fraction of about 0.5. The diameters of the two colloids we used are $5.2\mu\text{m} \pm 0.5\mu\text{m}$ and $10.0\mu\text{m} \pm 0.3\mu\text{m}$, whose polydispersity is negligible. The diameters are quite large, since NFS gives advantages with respect to classical LS for small wavevectors.

The colloids we measured are held in a cell with plane parallel windows. The diameter is about 4cm, since the sample and the beam intensity must be uniform on a length D, where D is given by Eq. (3.64). The thickness is about 2mm. We selected the tickness and the particle concentration in order to have a suitable attenuation of the main beam, about 1%. For ONFS measurements, the thickness of the cell and the volumetric particle density are enough to fulfill Eq. (3.55).

The liquid is held between the two windows by an O-ring; the parallelism between the windows is not critical, nor the optical quality of them. Since the measured scattered light comes from different regions of the sample, we must provide that it is homogeneous. This implies that the thickness must be uniform, but an optical quality allignment is far beyond what is needed.

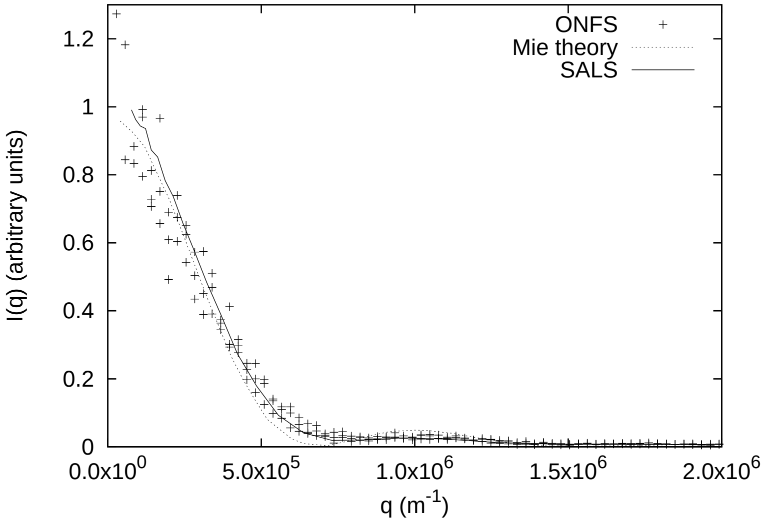

Figure 7.1: ONFS measurement of the 10.0μm colloid. A SALS measurement and a theoretical evaluation based on Mie theory are shown.

7.2 Measurements.

In Fig. 7.1, 7.2 and 7.3 are shown the results of ONFS measurement. The same samples have been analyzed also by a SALS instrument; the results are shown in the graphs.

In Fig. 7.4, 7.5 and 7.6 are shown the results of ENFS measurement. The same samples have been analyzed also by a SALS instrument; the result is shown in the graphs.

Both ONFS and ENFS measurements agree with the SALS measurement, but ONFS gives less accuracy.

7.3 What is the main source of error?

The ONFS data processing is based on Siegert relation; the correlation function is evaluated by Eq. (5.23). First, we average the correlation functions of each image. The error in the evaluation of the intensity correlation decreases as the square root of the number of the samples, and this dependence is intrinsic in the stochastical nature of the technique. Then, we evaluate the field correlation function, by extracting the square root of the difference between the mean intensity correlation and the square mean intensity. Thus we obtain a quantity which converges to the field correlation function as the fourth root of the number of samples.

On the contrary, ENFS gives directly the correlation function without any

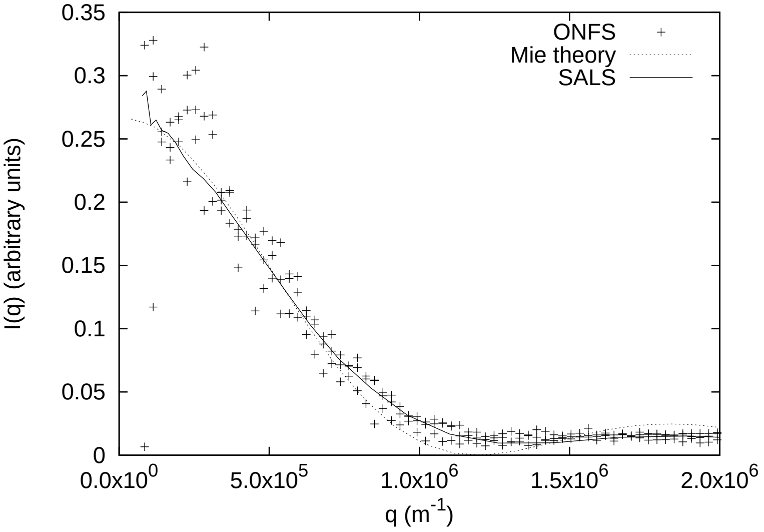

Figure 7.2: ONFS measurement of the 5.2μm colloid. A SALS measurement and a theoretical evaluation based on Mie theory are shown.

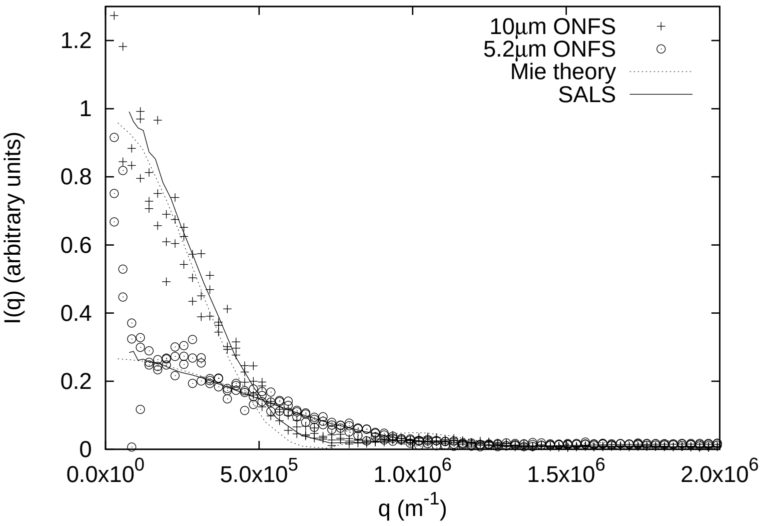

Figure 7.3: ONFS measurements of the two colloids. SALS measurements and theoretical evaluations based on Mie theory are shown.

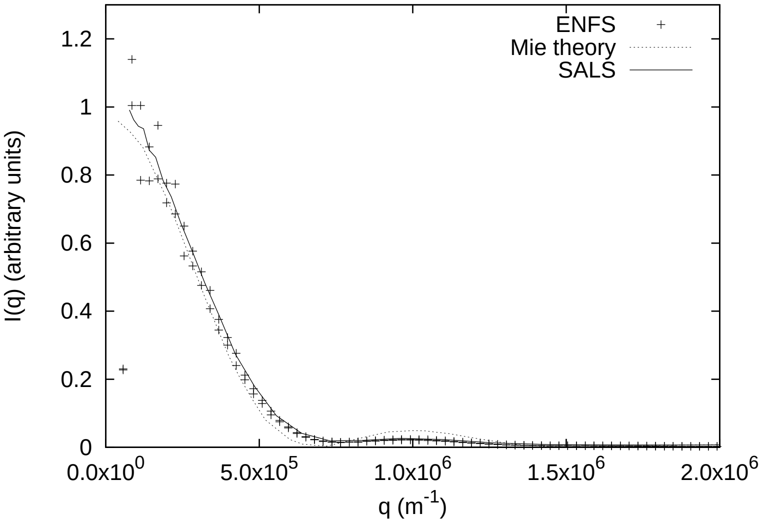

Figure 7.4: ENFS measurement of the 10.0μm colloid. A SALS measurement and a theoretical evaluation based on Mie theory are shown.

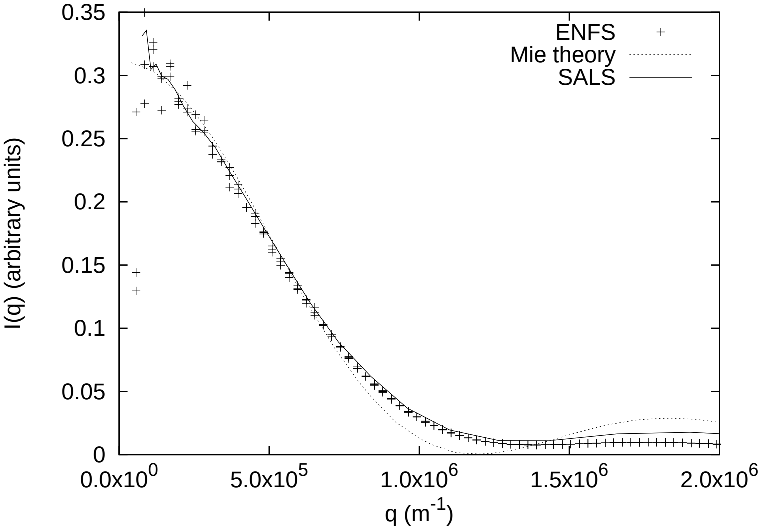

Figure 7.5: ENFS measurement of the 5.2μm colloid. A SALS measurement and a theoretical evaluation based on Mie theory are shown.

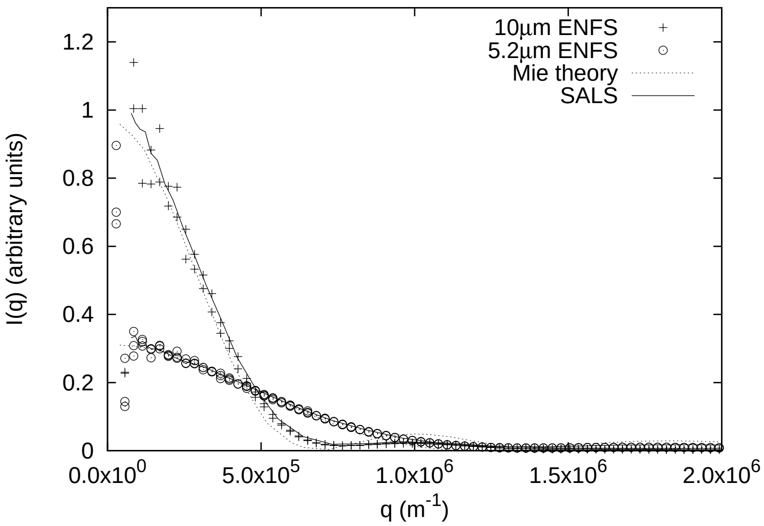

Figure 7.6: ENFS measurements of the two colloids. SALS measurements and theoretical evaluations based on Mie theory are shown.

extraction of square root. We can notice that the plateau of Fig. 6.6 and 6.7 are more plain than in Fig. 5.9 and 5.10. The noise on the plateau is then spread across all the power spectrum when the Fourier transform is performed.

The situation is worst than in dynamic light scattering. The reason is that we are working in two dimensions: in order that the power spectrum can be evaluated, the correlation function must approach 0 faster than $1/r^3$, while in one dimension, it must be faster than $1/r^2$. We can perform an angular mean, but we gain only a term $r^{-1/2}$.

These considerations should explain why ONFS data are much less accurate than ENFS and SALS ones: the problem is the slow statistical convergence as the number of samples increases. In order to test this explanation, we performed some numerical simulations. We used the SALS data to simulate a power spectrum. We created one hundred random fields, with gaussian probability and the given power spectrum. We obtained the homodyne and heterodyne signals, thus creating images similar to the ones we acquired during the experiments. Last, we processed the data with the above described algorithms. The simulations are only affected by the statistics: they are virtually free from any experimental error. In Fig. 7.8 and Fig. 7.7 we present, respectively, the results for the ONFS and ENFS simulations. They look quite similar to the corresponding experimental measurements of Fig. 7.6 and 7.3. This confirms that the main source of error, for our ONFS measurements, is the poor statistical quality of the samples. Since the quality increases as the fourth power of the number of the samples, we cannot make ONFS measurements better than ENFS ones, un-

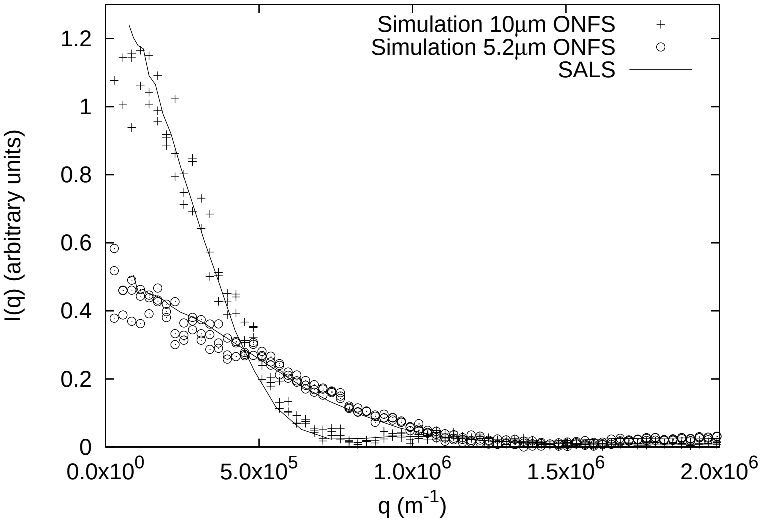

Figure 7.7: Simulations of ONFS measurements of the two colloids. SALS measurements are also shown.

less we process at least one million images: this is, for the moment, impossible.

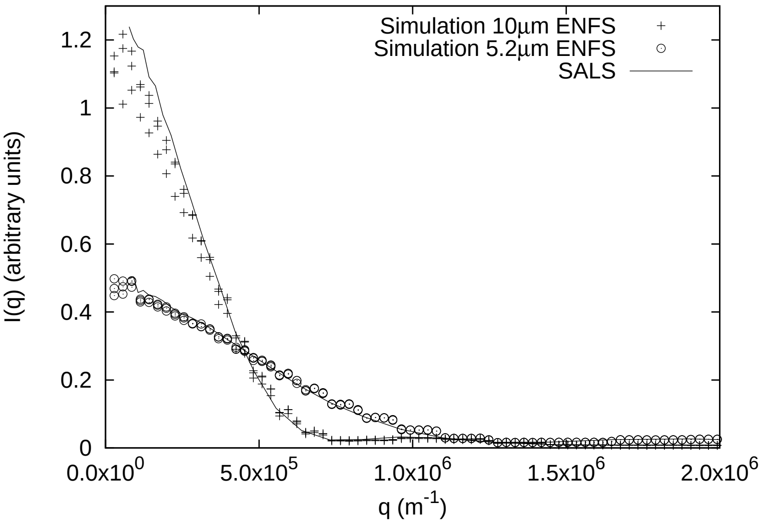

Figure 7.8: Simulations of ENFS measurements of the two colloids. SALS measurements are also shown.