Measuring Multimodal Colloid Size Distributions at Trace Concentrations

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The Laser Induced Breakdown Detection is capable of counting single colloids in aquatic media. Herefore, the beam of a pulsed, frequency doubled Nd:YAG laser is focused into the sample and a plasma is ignited selectively on colloids. The plasma plume is detected either by optical observations or by means of its shock wave with a piezo-detector. By increasing the energy of the laser pulse, the number of plasma ignitions increases likewise (so called 's-curves') and from this data colloid size and concentration is deduced. Particles down to 10nm in size are detected at ppt concentrations.

This 'classical' detection method only allows for the appraisal of a weighted mean size of the colloids. By use of a high quality TEM00 laser beam and an improved mathematical evaluation of the data, particle size distributions (PSD) can now be detected directly. Monomodal suspensions of well characterized spherical polystyrene particles are measured for calibration: s-curves of 20 nm, 30 nm, 40 nm, 50 nm, 70 nm and 100 nm are taken for five concentrations each. It can be shown, that the s-curves follow a simple mathematical function (a convolution of polynomial increase and exponential damping) with only two free parameters corresponding to size and concentration. A mixture of different sized particles results in a convolution of the s-curves corresponding to the respective monomodal samples (sum of inverse probabilities). In order to gain the size distribution of an unknown sample , the s-curve is taken with high statistics and the above sum of convoluted exponentials is fitted to the data. In order to reduce the number of free parameters and to "harden" the fit only the concentrations are allowed to be varied, whereas the size parameters remain fixed (i.e. the size distribution consists of only six fractions so far).

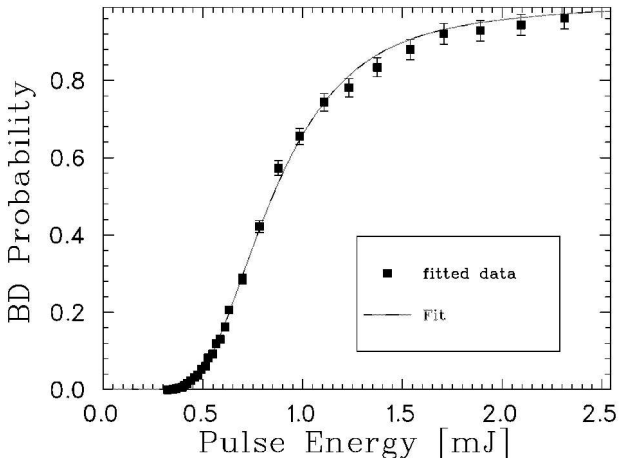

Fig.1: A synthetic trimodal colloid sample is measured by acoustical detection (s-curve)

Fig. 1 shows an example. A trimodal suspension (Polystyrene particles of 20 nm (1.5E8/ml), 50 nm (2.0E7/ml) and 100 nm (2.7E6/ml)) was measured as a function of laser pulse energy. Note the high quality of the data at low pulse energies which is crucial to achieve meaningful results. By use of the deconvolution, the size distribution displayed in the histogram in Fig.2 is obtained. The concentrations are reproduced within a 20% error. In the present state the size region between 20 and 100 nm is evaluated in six fractions and colloid concentrations down to 100 ppt can be characterized. Recent work is aimed at increasing the accessible size range from 10 to 1000 nm and lowering the detection limit.

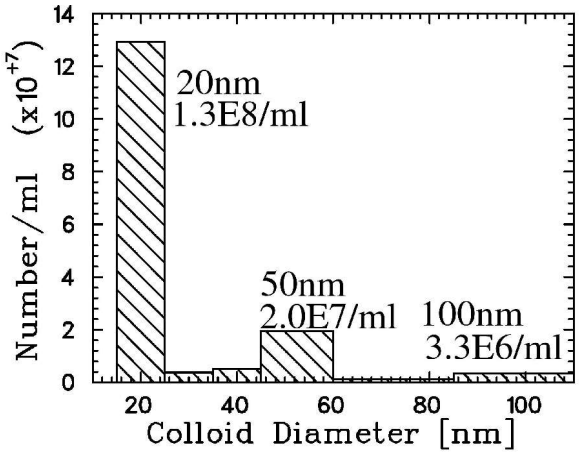

Fig.2: The particle size distribution (PSD) of a synthetic three modal colloid sample of polystyrene spheres is reproduced within 20% eroor: From the fitted curve of Fig.1 the PSD is appraised as shown in the histogram at the right.

Literature:
[1] C. Walther, C. Bitea, W. Hauser, J.I. Kim, F.J. Scherbaum, NIM B 195, 374 (2002)