properties of the dispersed particles and the dispersion medium, i.e. knowledge of their respective refractive indices is required for calculation of particle size distributions.

Alternative techniques

There is a wide variety of different instruments based on laser Doppler anemometry or velocimetry and diffraction measurements.

Automatic methods

Most of the instruments based on laser diffraction produce a full particle size analysis automatically, with data are presented in graphical and tabular form.

Photon correlation spectroscopy (dynamic light scattering)

Equivalent diameters

Hydrodynamic diameter, d_h, defined in Table 9.1.

Range of analysis

This is shown diagrammatically in Figure 9.17.

Sample preparation and analysis conditions

Particles are presented in liquid suspension.

Principles of measurement

In photon correlation spectroscopy (PCS), also called dynamic light scattering (DLS) and quasi-elastic light scattering (QELS), the intensity of scattered light at a given angle is measured as a function of time for a population of particles. The rate of change of the scattered light intensity is a function of the movement of the particles by Brownian motion. Brownian motion is the random movement of a small particle or macromolecule caused by collisions with the smaller molecules of the suspending fluid. It is independent of external variations, except the viscosity of the suspending fluid and its temperature, and as it randomizes particle orientations, any effects of particle shape are minimized. Brownian motion is independent of the suspending medium and although increasing the viscosity does slow down the motion, the amplitude of the movements

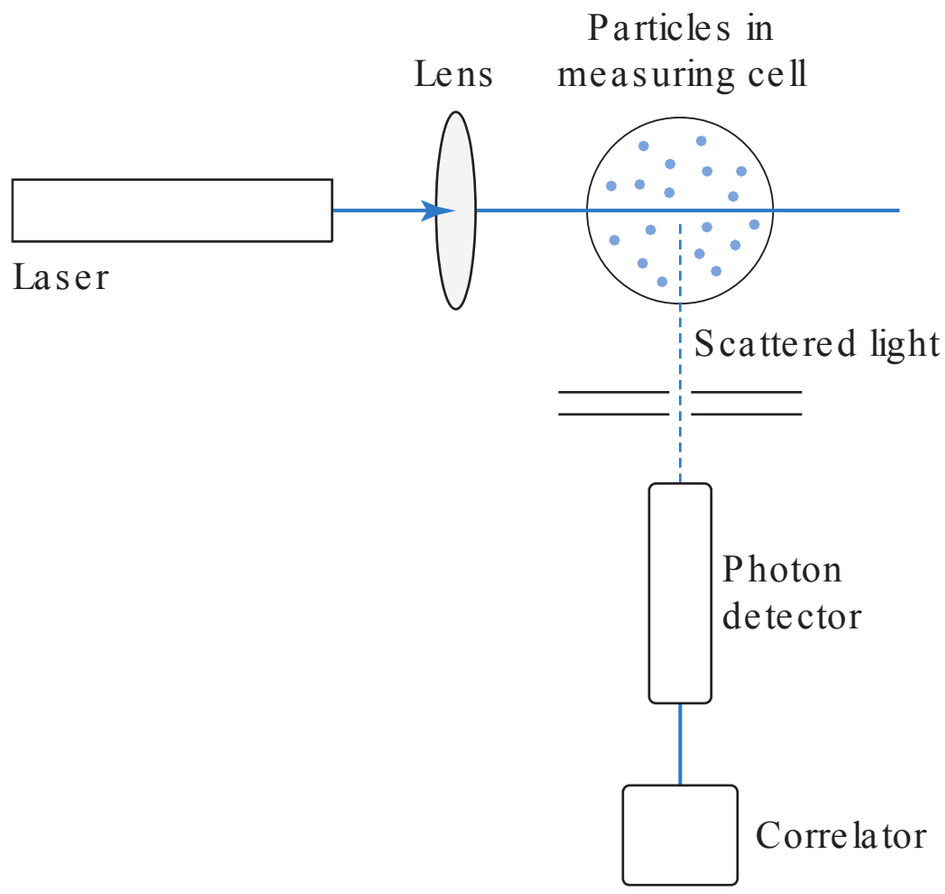

Fig. 9.19 • Schematic diagram of photon correlation spectroscopy particle sizer.

is unaltered. Because the suspended small particles are always in a state of motion, they undergo diffusion. Diffusion is governed by the mean free path of a molecule or particle, which is the average distance of travel before diversion by collision with another molecule. PCS analyses the constantly changing patterns of laser light scattered or diffracted by particles undergoing Brownian motion, and monitors the rate of change of scattered light during diffusion. In most instruments, monochromatic light from a helium-neon laser is focused onto the measurement zone, containing particles dispersed in a liquid medium (Fig 9.19). Light is scattered at all angles, and is often detected using a detector placed at an angle of 90°. The detection and spatial resolution of the fluctuations in the intensity of the scattered light, is converted via a digital correlator into size distribution data.

Brownian diffusion causes a three-dimensional random movement of particles, where the mean distance travelled, $\bar{x}$, does not increase linearly with time, t, but according to the following relationship:

$$\bar{x} = \sqrt{Dt} \tag{9.12}$$

where D is the diffusion coefficient.

A basic property of molecular kinetics is that each particle or macromolecule has the same average thermal or kinetic energy, E, regardless of mass, size or shape: