Laser diagnostics of optically trapped particles

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The optical trapping and manipulation of particles by laser beams have played a revolutionary role in areas of the physical, chemical and biological science. Investigations of both the chemical composition and the physical behavior of microparticles are very important for studying environmental pollutants in the atmosphere, medical applications, physics of aerosol, combustion, etc.

Aim of the paper is to study the evolution of single microdroplets in non-isothermal regime, employing an optical trapping technique combined with optical diagnostics. A “2 beam trap” for blocking micron-sized particles was utilized (Fig.1). In the “2 beam trap” configuration, the stable levitation of particle is obtained by using two coaxial counterpropagating TEM00 laser beams. In this configuration the stable equilibrium position doesn’t depend on the diameter and composition of trapped particle and the trapping is very stable. Thus, this trap is particularly suitable to study single droplet undergoing size and properties variations.

In the system was developed, a TEM00 beam from an Argon ion laser is split up into two beams with identical power and then focused in a quartz cell where the particles were trapped. With a laser power of about 1.2 W, latex spheres of 20 μm and 90 μm were stably (for some hours) trapped in water in the same position. In order to trap liquid droplets in air, a third vertical beam was utilized to decelerate free falling droplets. Then the two opposite beams were used to block one of the decelerated droplets. By using this configuration, droplets of 70 μm were trapped in quiescent air. Figure 1 shows the scheme of the optical trap.

Generalised Scattering Imaging, *GSI*, planar out-of-focus imaging technique was used to characterize trapped particles. To this aim a He-Ne laser beam was focalized to a sheet by a cylindrical lens and rotated to $\vartheta = 60°$ with respect to the optical axis of the imaging system. A 5X microscope objective and a lens were used to image out-of-focus pictures of the trapped droplet on a high speed CCD. Shadowgraphy was also applied to visualize droplets in the trap. To this aim a diode laser @ $\lambda = 688$ nm was used. Shadowgraphs were obtained by using the same imaging systems utilized for GSI measurements. The strong light scattering from trapped droplets due to the argon laser beams was cut away by a $\lambda = 600$ nm high pass filter. In out-of-focus images, a peculiar pattern of scattering intensity oscillations appears inside every defocused droplet picture. From the angular spacing GSI is able to measure the size of droplets independently from their refractive index (i.e., temperature and composition).

A solution of latex particles in water was used in preliminary tests to verify the reliability of the experimental system and for calibration. In a second series of experiments, 70 μm n-tetradecane droplets were trapped and heated in air. Their diameter variation with time was inferred by measuring the spacing of scattering oscillations in out of focus image sequences. Defocused droplet sequences were captured by means the high speed imaging system placed in out of focus (max rate 2000 frames/sec. Figure 2 shows the normalized squared diameter for different heating regimes.

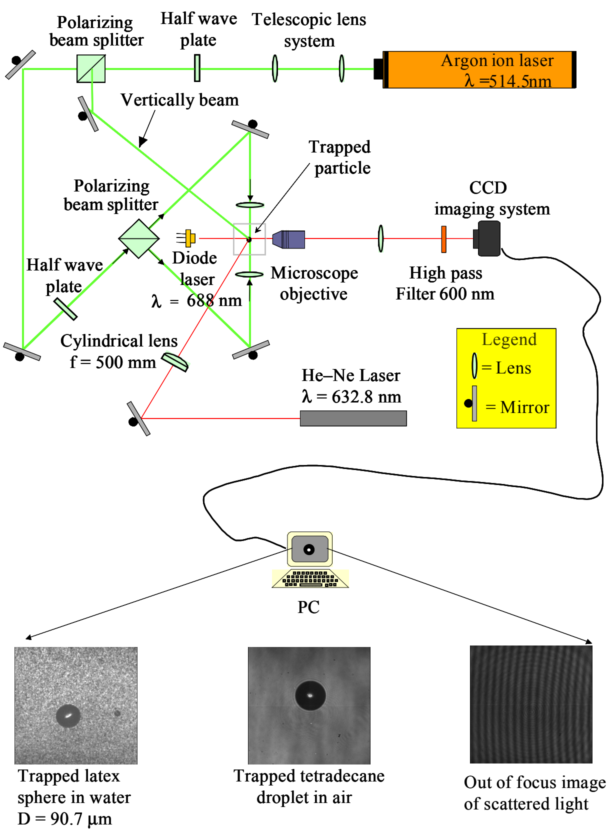

Fig. 1 Experimental set up

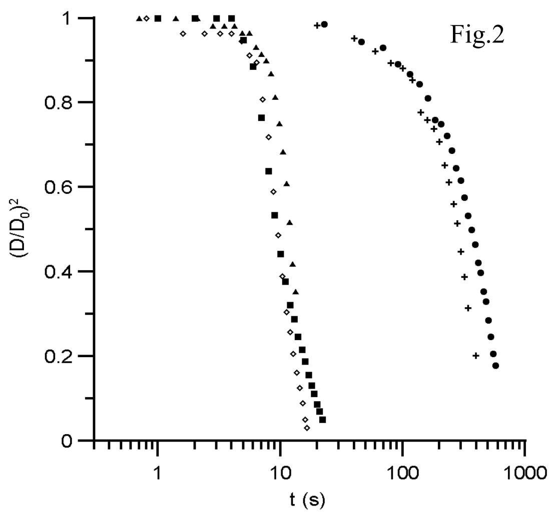

Fig.2