SHORTER CONTRIBUTION

A method for an experimental determination of the growth process of water droplets

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When condensation nuclei are injected into a chamber where supersaturation conditions prevail, water droplets start to form. The growth process is then dependent on the physical and chemical characteristics of the nuclei and on the process of diffusion of water vapour (Jiusto, 1967). The scattering cross-section for monochromatic light is given by the Mie solution to the problem of scattering by small spheres (Penndorf, 1962). From the theory it follows that the intensity of the scattered light at a scattering angle $\theta = 90°$, fluctuates with increasing droplet size (Fig. 1). The intensity variation of the scattered light caused by the growth of the droplets can be measured by a photomultiplier and recorded as a function of time. In this way the droplet radius at any instant—before all the droplets fall out of the incident beam—can be determined. If the supersaturation conditions are known, the relationship between the growth rate of the droplet size and the degree of supersaturation is also established for given condensation nuclei.

The method is based on theoretical calculations with correlate each Mie peak to a known size parameter α.[1] The time intervals between the consecutive peaks are related to the growth process. This method does not require that all the droplets remain within the light beam during the experiment, since only the time between peaks is being measured. However, the measurements can provide a direct estimate of the number of condensation nuclei, by comparing the intensities—i.e. the heights of the peaks—observed in the different cases. A condition is that not too many droplets disappear from the beam.

Our experimental system consists of He–Ne laser as the light source (6328 Å, 2 mW), a thermal diffusion cloud nuclei chamber (T.D.C.N.C.) (Gagin & Terliuc, 1968) in which supersaturation conditions can be controlled, and a IP28 RCA photomultiplier which measures the laser light scattered at 90° by droplets formed in the T.D.C.N.C. We present here some of the results of the measurements taken at 0.4, 0.5 and 1 % supersaturation (Fig. 2, I–V: intensity for scattering angle $\theta = 90°$ as a function of time):

1. The time interval between two successive peaks, decreases with increasing supersaturation (Fig. 2, I: S = 0.4 %; Fig. 2, II–III: S = 0.5 % and Fig. 2, IV–V: S = 1 %).

2. Below a certain limit, which is set by the water vapour content in the system, the number concentration of condensation nuclei, which determines the height of the peak, does not influence the growth process (Fig. 2, II–III).

3. In conditions of low supersaturation the type and size distribution of the condensation nuclei play a significant role in the growth process. Thus, in Fig. 2, I, three different groups can be seen for each peak, which is in accordance with theory (Jiusto, 1967).

4. After 5–8 seconds (depending on the supersaturation conditions) the signal has decreased significantly due to the fallout of droplets. Calculation of the downward velocities gives a result which is in accordance with the observed 5–8 seconds that the droplets spend in the laser beam. This shows that the signal recorded after 5 seconds cannot be correlated with the initial number of droplets.

The method described above can also be used for determining the type of condensation nuclei, since this influences the first stages of

[1] $\alpha = 2\pi\gamma/\lambda$ where γ is the droplet radius and λ the wavelength.

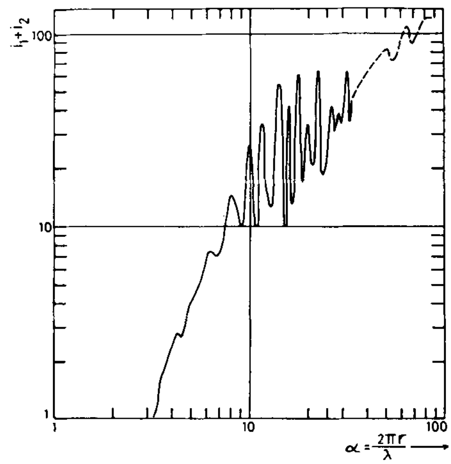

Fig. 1. Theoretical intensity $i_1 + i_2$ for scattering angle $\theta = 90°$, as a function of size parameter (Jiusto, 1967).

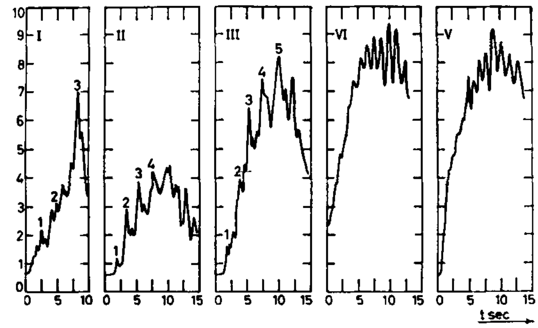

Fig. 2. Experimental intensity $i_1 + i_2$ (arbitrary units) for scattering angle $\theta = 90°$, as a function of time. I: S = 0.4 %; II–III: S = 0.5 %; IV–V: S = 1 %.

the growth process for low degree of supersaturation. On the other hand, once the rate of growth is known to a sufficient degree of accuracy, the system can be used for plotting the scattered intensity (for $n = 1.33$) against $\alpha = 2\pi\gamma$ (microns)/0.63 < 50 as a check of the applicability of the Mie-formulas.

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