A Review of Laktionov's Isothermal Cloud Nucleus Counter

D. J. ALOFS AND J. PODZIMEK

Dept. of Mechanical and Aerospace Engineering and Graduate Center for Cloud Physics Research, University of Missouri—Rolla

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A. G. Laktionov has developed an isothermal cloud nucleus counter, in which the size of water droplets formed at 100% humidity is measured, and, from this measured size spectrum, the supersaturation spectrum of the nuclei is deduced. Laktionov has published (1972) a description of his chamber, but, to our knowledge, an English translation is not available. Since Laktionov's chamber may provide an alternative to several recently developed thermal diffusion chambers (e.g., Hudson and Squires, 1973; Sinnarwalla and Alofs, 1973), we would like to review Laktionov's paper and offer some comments.

In the first part of his paper, Laktionov develops a simple relation between the critical supersaturation S_k of a nucleus and its equilibrium radius at 100% humidity, r_{100}. The successful interpretation of the results from his chamber relies on there being only one such relation for practically all the nuclei counted. Laktionov uses a similar relation to the one given by Fletcher (1962) for supersaturation (S) and radius (r):

$$S=a/r-b/r^3. \quad (1)$$

Here $a=2\sigma M/(\rho RT)$, where σ is the surface tension of the solution droplet, M the molecular weight of water, ρ the density of water, R the gas constant, and T the absolute temperature. Laktionov considers the dry nucleus, of mass m_0, to consist of a soluble part, of mass Gm_0, and an insoluble part, of mass $(1-G)m_0$. The factor b is then given as $b=3iGm_0M/(4M_p\pi\rho)$, where i is the van't Hoff factor and M_p the molecular weight of the salt.

Laktionov then shows that

$$r_{100}=0.385a/S_k. \quad (2)$$

Thus an important conclusion that the relation between the critical supersaturation and the equilibrium radius at saturation does not depend upon G, the solubility mass fraction. Moreover, the quantity a depends only weakly upon the type of salt, so that (2) is assumed to always give

$$S_k=0.04/r_{100}, \quad (3)$$

with S_k in percent and r_{100} in microns.

Laktionov supports the above assumption by experimental comparison between his isothermal chamber and a thermal diffusion chamber. Using atmospheric air at 1500 m altitude, the thermal diffusion chamber was sequentially operated at supersaturations of 0.1, 0.16, 0.25 and 0.4%. On the same flight, the isothermal chamber gave nuclei concentrations at seven different supersaturations, ranging from about 0.05 to 0.25%. The correlations between the instruments from this limited data are very good, indicating that (3) is valid for the aerosol tested.

We would like to comment, however, that there is evidence that some atmospheric aerosols consist of a significant number of cloud nuclei coming from industrial sources (e.g., Fitzgerald and Spyers-Duran, 1973). It is to be expected that these nuclei would contain surface active materials. Assuming that (2) is valid for such contaminated nuclei, the constant a would be decreased, due to the fact that surface-active materials decrease σ, the surface tension. Thus, if (2) is valid for such contaminated nuclei, one concludes that the effect of the surfactants would be to make the nucleus more active. The opposite has been found to be true in experiments by Storozhilova (1971) and by Silaev *et al.* (1971) using NaCl nuclei contaminated by cetyl alcohol surfactant. Since the effect of contaminants is really a matter of question, we suggest that the use of Laktionov's chamber, as a replacement for a thermal diffusion chamber, might be especially unsuitable for atmospheric studies of the effect of air pollution on cloud nuclei. Instead, it might be advisable to use both instruments together for such studies.

As to the advantages of Laktionov's chamber, we would like to stress the simplicity of it, both in design and in operation. Suitable optical counters are available commerically (e.g., from Royco, Climet, and Bausch and Lomb), so that one could build an instrument of Laktionov's type by merely mounting a vertical tube, with a wet inner wall, on the inlet nozzle of a commercial optical counter. As to simplicity of operation, a supersaturation spectrum, down to very low supersaturations, is obtained in one steady-flow operation. The lower limit of supersaturation has not been analyzed and may depend on the degree to which large water drops, say 5 μm radius, impact on the capillary tube in the optical counter. We conclude by recommending Laktionov's chamber for future study and for consideration in field or laboratory programs.

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