Diffusion, Brownian Movement, Loschmidt-Avogadro's Number and Light

A. Einstein's and M. v. Smoluchowski's theory[1] of the Brownian molecular movement describes only statistical fluctuations of impacts upon matter due to thermal agitation of molecules. Prior to this theory the influence of light was considered, but subsequently has been neglected. The following method which the author has developed allows the longest and therefore the most exact investigation on Brownian movement to be made.[2] The velocity of rise, as also the velocity of fall, of single submicroscopic test particles is measured in the electric field of the small condenser of the author's design as often as desired. It is known that this method which was later used by Millikan gives smaller charges than the electronic charge in contradiction to Millikan's results on oil drops in a condenser 20 times as large. These small charges were found on particles whose sphericity and normal density could be proved in this way: The velocity of fall of such a particle was measured at increasingly high gas pressures, the particle was then removed and its size determined by new microscopic methods.[3] Naturally the observations were made in the weakest diffused light. Only solid spheres can be examined since they do not vaporize and since they can be collected. Liquid drops such as oil evaporate, and are distorted upon collection on a plate. The mobility, according to Einstein, can be determined from the deviations of the velocities (fall or rise) from their mean values. Once the weight of the particles is known then Loschmidt-Avogadro's number can be obtained.[4]

However, when an uncharged particle is irradiated by intense light coming from any direction (having any wave front normal) it moves in a homogeneous electric field in or against the direction of the electric lines of force (electrophotophoresis)[5] and in a homogeneous magnetic field in or against the direction of the magnetic lines of force (magnetophotophoresis) like a single north or south pole ("magnetic ion").[6] The magnetophotophoretic force in intense light is so great that motion occurs even in the weak geomagnetic field[7] in or against the direction of the geomagnetic lines of force. Other observers neglected these facts and this is the reason for the manifold differences in the examinations of the theory of the Brownian movement to which I have drawn attention for three decades. The effect in liquids should be still more pronounced since much more powerful illumination and frequently much smaller particles were used.

It will be clear to everybody now that Loschmidt-Avogadro's number can be determined correctly only if the observations are made in darkness and if the influence of light is excluded in a proper way such as the author did in his extensive investigations whose results indicated charges smaller than the electron. Only when such a method is used, can the resulting Loschmidt-Avogadro's number be claimed to be correct. This problem will have to be solved in the future.

Thus Brownian movement and diffusion in light consist of at least two components, (1) the mere statistical in sense of the theory and (2) magnetophotophoresis in the geomagnetic field; sometimes perhaps also electrophotophoresis. Consequently diffusion taking place in nature all by itself depends upon the intensity of the light falling on the diffusing matter. This the author not only observed in his condenser but in general by diffusion experiments.

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[1] A. Einstein, Ann. d. Physik **17**, 545 (1905); **19**, 371 (1906); M. v. Smoluchowski, Ann. d. Physik **21**, 756 (1906); First experiments in gases, F. Ehrenhaft, Wiener Ber. [IIa] **116**, 1175 (1907).
[2] F. Ehrenhaft, Wiener Akad. Anz. **10**, 118 (1910); Wiener Ber. [IIa] **119**, 815 (1910); Physik. Zeits. **11**, 619 (1910); Summary: Physik. Zeits. **39**, 673 (1938).
[3] F. Ehrenhaft, Physik. Zeits. **39**, 673 (1938).
[4] For instance, E. Schrödinger, Physik. Zeits. **16**, 289 (1915).
[5] G. Placzek, Zeits. f. Physik **49**, 601 (1928); F. Ehrenhaft and D. K. Konstantinowsky, Wiener Akad. Anz. **9** (March 18, 1920).
[6] F. Ehrenhaft, Comptes rendus **190**, 263 (1930); Physik. Zeits. **31**, 478 (1930); Phil. Mag. **11**, 140 (1931); Vienna Diss. (Ph.D.): E. Reeger, Zeits. f. Physik **71**, 649 (1931); M. Gradmann (1934) and N. Judenberg (1938).
[7] F. Ehrenhaft, Ann. de Physique **13**, 151 (1940). See also: F. Ehrenhaft, Phys. Rev. **57**, 562 (1940); **57**, 659 (1940).

Air Mass Effect on Cosmic-Ray Intensity

Loughridge and Gast[1] have discussed under the above title the effects of the cold and warm fronts on the intensity of cosmic rays. We have made similar studies on the cosmic-ray data obtained during the period 1937–1939 with a Steinke apparatus and an IPCR cosmic-ray meter both inside 10 cm Pb. The location of the fronts was determined from the synoptic charts published by the Central Meteorological Observatory, Tokyo. We investigated ten cases, of which two were warm fronts and eight were cold.

Hourly means of observed cosmic-ray intensities were reduced to the values at a standard pressure 755 mm Hg by using a true absorption coefficient $\mu = 9.5\times10^{-3}$/cm Hg for air. On plotting cosmic-ray intensities as ordinate and time as abscissa, we found that the approach and passage of a warm front produced a gradual but pronounced decrease in cosmic rays as shown in Fig. 1. This represents the results for the case of a remarkable warm front, which accompanied heavy rainfalls over the wide district surrounding Tokyo during the period June 28–July 5, 1938.[2] The other warm front studied gave a similar change

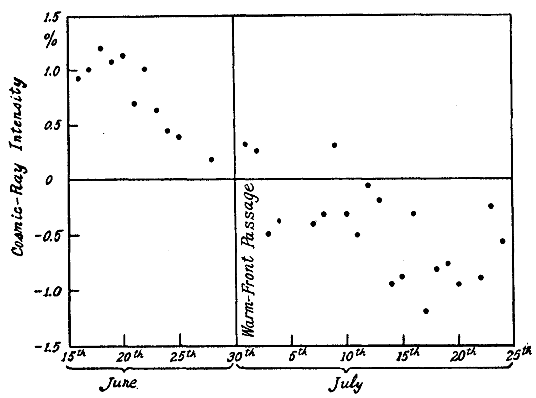

FIG. 1. Effect on cosmic-ray intensities of the approach and passage of a warm front.