

Kinetic equation for Smoluchowski's diffusion

Smoluchowski's diffusion, [1], it is a diffusion in an external field is studied, and a general kinetic equation valid within the framework of classical statistical mechanics is found.

We apply Stecki's projection operator method, [2], to obtain a kinetic equation for an auxiliary distribution function $f(k, v_1, t)$. This function yields the intermediate scattering function $I_s(k, t)$, which is a Fourier transform of van Hove's function $G_s(r, t)$. The function $G_s(r, t)$ gives the probability of finding in a equilibrium system a given (marked) particle at (r, t) , if it was known to be at the position $r=0$ at the time $t=0$. A kinetic equation of the convolution type for the time evolution of the distribution function $f(k, v_1, t)$ is given.

Diffusion problems studied in the time scale comparable with time of particles collision lead to kinetic equations which for step-wise potentials are functional equations in the velocity space.

We start, as usually in statistical physics from Liouville's theorem, which is a key theorem in classical statistical and Hamiltonian mechanics. The gas is composed of N particles. We pay a particular attention to Lorentz' gas with $N-1$ immovable particles-scatterers, between which a light particle number 1 is moving, and to Brownian diffusion (one heavy-marked particle among $N-1$ light particles). The second case is a natural generalization of Smoluchowski's equation.

[1] Subrahmanyan Chandrasekhar, Mark Kac, Roman Smoluchowski, Marian Smoluchowski - his life and scientific work, ed. by R. S. Ingarden, Seria: Polish Men of Science, PWN - Polish Scientific Publishers, Warszawa 1999.

[2] Jan Stecki, On the kinetic equation nonlocal in time for the generalized self-diffusion process, Journal of Computational Physics 7 (3) 547-553 (1971).

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