Kinetics of Bogolyubov Brownian oscillator model and the fluctuation-dissipation theorem

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Kinetics of a system described by Langevin equation

$$\dot{\eta}_a(t) = \sum_b \int_0^t d\tau\, \mu_{ab}(\tau)\eta_b(t-\tau) + f_a(t), \qquad (1)$$

is considered. Here $\mu_{ab}(\tau)$ is a memory kernel, which defines processes in the system including dissipation, $f_a(t)$ are Gaussian random force. Problem of the fluctuation-dissipation theorem (FDT) derivation for equation (1) is discussed. The FDT gives relation between the kernel $\mu_{ab}(\tau)$ and correlation function $\varphi_{ab}(t-t') \equiv \overline{f_a(t)f_b(t')}$ and is proved by us with phenomenological methods. The FDT shows that in the absence of memory effects the correlation function $\varphi_{ab}(t) \sim \delta(t)$. Nevertheless, in some papers one can find opposite assumption.

As an example of a system described by equation (1) we consider model of a one-dimensional harmonic oscillator in equilibrium medium which consists of non-interacting harmonic oscillators. This model is an exact solvable one and was studied by Bogolyubov [1] to give an example of transition of a system to equilibrium. In the framework of this model we study assumptions on which our proof of the FDT is based. In paper [1] Bogolyubov derived a kinetic equation for this model as a strict mathematical fact in the limit of small interaction of the Brownian oscillator with the bath. We proposed a derivation of this kinetic equation based on Bogolyubov functional hypothesis to discuss domain of applicability of this hypothesis. Effective initial conditions for this kinetic equation were studied too. Some statements concerning kinetics of this model were verified by a computer simulation.

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1. Bogolyubov N.N. *About some statistical methods in mathematical physics.*– Kiev: AN UkrSSR, 1945, P.115–137 (in Russian).