Bogolyubov reduced description method in kinetics of quasi-steady-state catalysis

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Catalytic kinetics has been investigated in the framework of the Michaelis-Menten model for enzyme kinetics. In this model [1] in the system there are four components: initial matter (substrate), catalyst, bound state of substrate and catalyst (complex), product (structural modification of the substrate). Kinetics of this model is described with equations:

$$\dot{x} = a(u - z_0)x + bu, \quad \dot{u} = -(ax + b + c)u + axz_0 \tag{1}$$

and conservation laws $z = z_0 - u$, $y = x_0 - x - u$. Here x, z, u, y are concentrations of the corresponding components, x_0, z_0, u_0, y_0 are their initial values, a, b, c are constants of reaction velocities. We study the case in which $x_0 \sim \lambda^0$, $z_0 \sim \lambda^1$, $u_0 = 0$, $y_0 = 0$, where λ is small parameter of the theory. The investigation is based on the Bogolyubov reduced description method (see, for example, [2]). We assume that quasi-steady-state stage of evolution of the system is observed after some transition period (at $t \gg \tau_0$). At this stage concentration of the complex $u(t)$ is a function $u(x(t))$ of concentration of the substrate $x(t)$ and function $u(x)$ does not depend on initial state of the system (the functional hypothesis). Therefore, for times $t \gg \tau_0$ we obtain a closed equation for concentration of the substrate $\dot{x}(t) = L(x(t))$. In this situation one has to use effective initial condition to this equation $\tilde{x}_0$ instead of real one x_0 [2]. Values $u(x), L(x), \tilde{x}_0$ were calculated by us in the perturbation theory. The developed theory was compared in computer simulation with exact one based on equations (1). We observed an excellent agreement of both theories.

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2. Akhiezer A.I.,Peletminsky S.V. *Methods of Statistical Physics.*– Oxford: Pergamon Press, 1981, 368 p.