Peculiar Features of Quantum Kinetic Processes in Biosystems

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The application of the nonequilibrium density matrix method to the study of the transient and transport processes in various biological systems under the influence of external factors such as regular and stochastic fields, temperature, and ligand concentration is performed. Characteristic features of the application of the method are related to structural peculiarities of the biological systems as complex macromolecular assemblies with high degrees of heterogeneity, functional specificity and flexibility, as well as the different types of internal degrees of freedom that may differently interact with the vibrational degrees of freedom of the environment. Special attention is paid to obtaining coarse-grained kinetic equations which describe the averaged time evolution of the probabilities of population of the states of an open quantum system, brought about through the transition and transfer rates involved [1,2]. The effectiveness of the method is demonstrated by the analysis of the important kinetic processes associated with the participation of a limited number of only relevant biosystem states. Several examples are the following: (i) Bridge-mediated and proton-assisted two-electron transfer reactions in proteins. (ii) Explanation of two nanoscale effects observed in neurophysiological experiments on the multi-subunit integral proteins of biological membranes. (iii) Oxygen-mediated triplet excitation transfer in biosystems.(iv) The open-loop hysteresis of bimodal type characteristic for the blockage of calcium ion channels by nickel ions in muscle cell membranes.

1. Petrov E. G. Coarse-grained kinetic equations for quantum systems. Eur. Phys. J. Special Topics, 2013, 216, 205-212.
2. Teslenko V. I., Petrov E. G. Regularization of environment-induced transitions in nanoscopic systems, 2016, 61, 627-647.