Contribution ID: **60**   Type: **Poster**

Time-dependent diffusive interaction in the absorbing systems: "sink-sink" and "wall-sink"

A brief survey of known analytical methods to obtain a generalization of classical Smoluchowski's formula for the trapping reaction rate coefficient [1] including effects of diffusive interaction in domains of complex geometry [2] is given.

Then we present an analytical approach in order to investigate the time-dependent diffusive interaction between stationary uncharged sinks of different radii. The analytical method to solve the diffusion problems for such complex domains is based on so-called addition theorems. By means of the addition theorems for the modified spherical Bessel functions we found the general analytical solution to the corresponding Laplace transform of the initial boundary-value problem for the diffusion equation, describing an important particular case of two sinks under Smoluchowski's boundary conditions.

Using obtained exact solution we propose a new correction to the known monopole approximation and compare it with previously known other time-dependent approximations. The characteristic relaxation time for the transient rate coefficients of absorption is also calculated. In addition the exact long-time asymptotics for the absorption rate of diffusing particles into every sink is derived. Besides analytical formulae, this paper comprises a number of numerical results that demonstrate the accuracy and the efficiency of our approach to study the diffusive interaction effects in the systems: "sink-sink" and "wall-sink".

[1] S. A. Rice, Diffusion-limited reactions, Amsterdam: Elsevier, 1985.
[2] M. Galanti, D. Fanelli, S. D. Traytak, and F. Piazza, in Chemical kinetics beyond the textbook, edited by R. Metzler, G. Oshanin, and S. Redner, New Jersey, World Scientific, 2020, (pp. 321-352).

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