Renormalization group analysis of two-species reaction-diffusion system: Crossover between long-range and short-range spreading

M. Hnatič[1,2,3], **M. Kecer**[1] **and T. Lučivjanský**[1]

[1]*Faculty of Sciences, P.J. Šafárik University, 04154 Košice, Slovakia,*
[2]*Institute of Experimental Physics, Slovak Academy of Sciences, Watsonova 47, 040 01 Košice, Slovakia,*
[3]*Bogoliubov Laboratory of Theoretical Physics, JINR, 141980 Dubna, Moscow Region, Russia.*
E-mail: matej.kecer@student.upjs.sk

In this work we focus on two-species reaction-diffusion system with the reactions $A+A \to (\emptyset, A)$, $A+B \to A$, with general diffusion constants. Such a system was studied earlier at and below its upper critical dimension $d_c = 2$ in [1, 2], and also in the presence of long-range spreading with fractional Laplace operator $\partial^\sigma \equiv \partial^{2(1-\alpha)}$ [3]. In the latter case, however, only long-range limit was explored ($\alpha \gg \varepsilon$), where $\varepsilon = d_c - d = 2 - d$. Here, we study the hybrid regime in which parameters α and ε are of the same order, i.e. $\alpha = O(\varepsilon)$. Our primary theoretical tool is field-theoretic perturbative renormalization group augmented with the approach of Honkonen and Nalimov [4]. The model is renormalized to all orders of perturbation theory, stable long-time asymptotic regimes are identified and time-decay exponent of respective particle densities is calculated.

References

[1] R. Rajesh and O. Zaboronski, *Survival probability of a diffusing test particle in a system of coagulating and annihilating random walkers*, Phys. Rev. E **70**, 036111 (2004).

[2] B. Vollmayr-Lee, J. Hanson, R. S. McIsaac, J. D. Hellerick, *Anomalous dimension in a two-species reaction-diffusion system*, J. Phys. A: Math. Theor. **51**, 034002 (2018).

[3] D. Shapoval, V. Blavatska, M. Dudka, *Survival in two-species reaction-diffusion system with Lévy flights: renormalization group treatment and numerical simulations*, J. Phys. A: Math. Theor. **55**, 455002 (2022).

[4] J. Honkonen and M.Yu. Nalimov, *Crossover between field theories with short-range and long-range exchange or correlations*, J. Phys. A: Math. Gen. **22**, 751 (1989).