

Long-range hops in a two-species reaction-diffusion system: renormalization group and numerical simulations

Tuesday, 21 December 2021 11:50 (20 minutes)

We consider the reaction-diffusion system of two-species with an anomalous superdiffusion undergoing the annihilation and coagulation reactions $A + A \rightarrow (0, A)$ as well as the trapping reaction $A + B \rightarrow A$. The superdiffusion is modeled via long-ranged Lévy flights represented by random walks with step-lengths obeying a Lévy distribution $P(r) = r^{-d-\sigma}$ (a heavy-tailed probability distribution) with control parameter $0 < \sigma \leq 2$. This system for the case of the ordinary diffusing Brownian particles is known to demonstrate scaling of particle density and density correlation function of target particles B with nontrivial universal exponents including anomalous dimension for $d \leq d_c$ (fluctuation-dominated kinetics), where $d_c = 2$ is the upper critical dimension [1, 2].

It is well-known, that replacing the diffusive propagation with long-ranged Lévy flights modifies the dynamics of reactive systems [3]. Moreover, when the diffusion is anomalous as when the particles perform such Lévy flights, the upper critical dimension depends on the Lévy index σ [3, 4]. We are interested in the question how superdiffusion modifies the scaling of observable quantities below the upper critical dimension $d \leq d_c = \sigma$. We have applied the renormalization group formalism [5] for the system under study and calculated the decay exponents of the particle density as well as the density correlation function in the case of the Lévy flights. We have performed the numerical simulations of the studied system as well, obtained quantitative estimates for the decay exponents are in good agreement with our analytical results [6].

- [1] R. Rajesh, O. Zaboronski, *Phys.Rev.E* **70**, 036111 (2004)
- [2] B. Vollmayr-Lee, J. Hanson, R.S. McIsaac, J.D. Hellerick, *J.Phys.A : Math. Theor.* **51**, 034002 (2018); *ibid.* **53**, 179501 (2020)
- [3] H. Hinrichsen and M. Howard, *Eur.Phys.J.B* **7** 635 (1999)
- [4] D. C. Vernon, *Phys.Rev.E* **68** 041103 (2003)
- [5] U. C. Täuber, *Critical Dynamics: A Field Theory Approach to Equilibrium and Non-Equilibrium Scaling Behavior* (Cambridge University Press, Cambridge, 2014)
- [6] D. Shapoval, V. Blavatska, M. Dudka, *in preparation* (2021).

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Session Classification: Statistical Theory of Many-body Systems

Track Classification: Statistical Theory of Many-body Systems