Nonlocally interacting particle systems: Lévy flights *versus* Gaussian jumps

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Model:

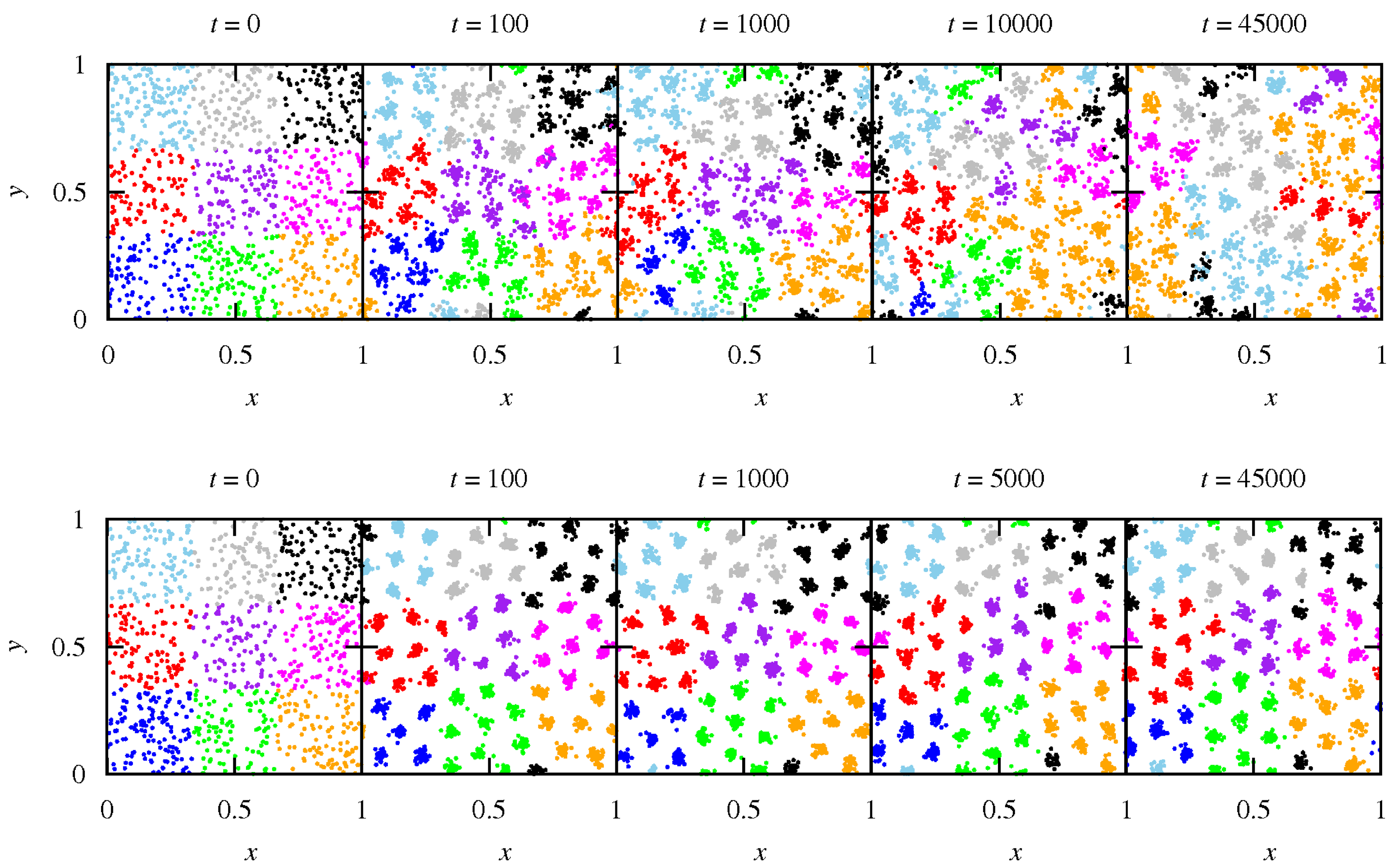
We consider a system initially ($t = 0$) consisting of N_0 particles and placed randomly in the $L \times L$ square domain with periodic boundary conditions. The particles perform a 2D continuous time random walk (CTRW) and undergo reproduction or death. In the case of reproduction, the new bug is located at the same position as the parent particle. The death rate is assumed to be constant, fixed to $r_d = 0.1$, whereas the birth rate is assumed to be determined by the crowdedness of the neighborhood; it is chosen as $r_b = 1 - 0.02 \cdot N_R^i$; N_R^i is the number of particles which are at a distance smaller than R ($R = 0.1$ if not marked differently) from particle i.

In order to simulate the CTRW leading to normal diffusion, the exponential inter-event time probability distribution function (PDF) is assumed together with a Gaussian jump length PDF.

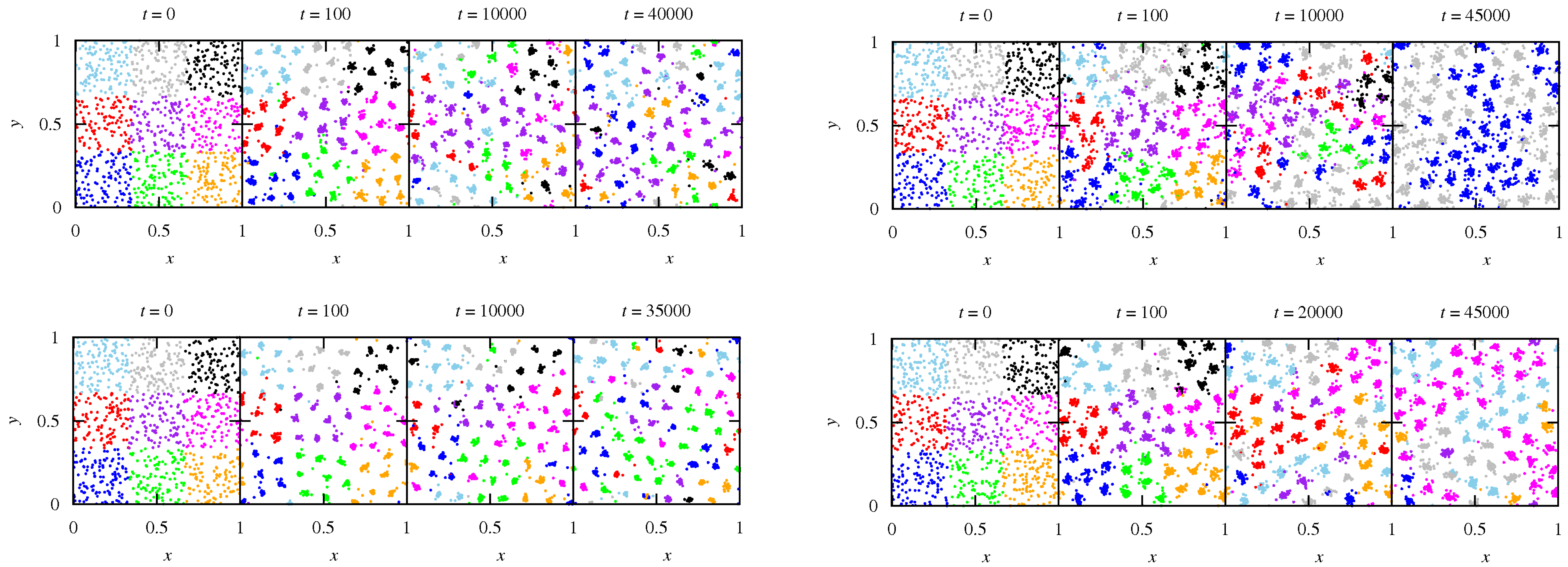
Modeling the system with Lévy flights, we assume for the inter-event times the exponential PDF and for the space steps a symmetric Lévy stable PDF, which behaves asymptotically as $\lambda^{-\mu-1}$ ($\lambda \to \infty$), with the Lévy index $1 < \mu < 2$, leading to a finite average step length but diverging variance.

In the figures, at time $t = 0$, in order to follow the system, we have divided the particles according to their initial position into 9 groups characterized by different colors; if a particle reproduces, the newborn particle assumes the same color as the parent.

Time evolution of the system with **Gaussian jumps** for different values of diffusion coefficient; top: $\varkappa = 4 \cdot 10^{-5}$; bottom: $\varkappa = 10^{-5}$.

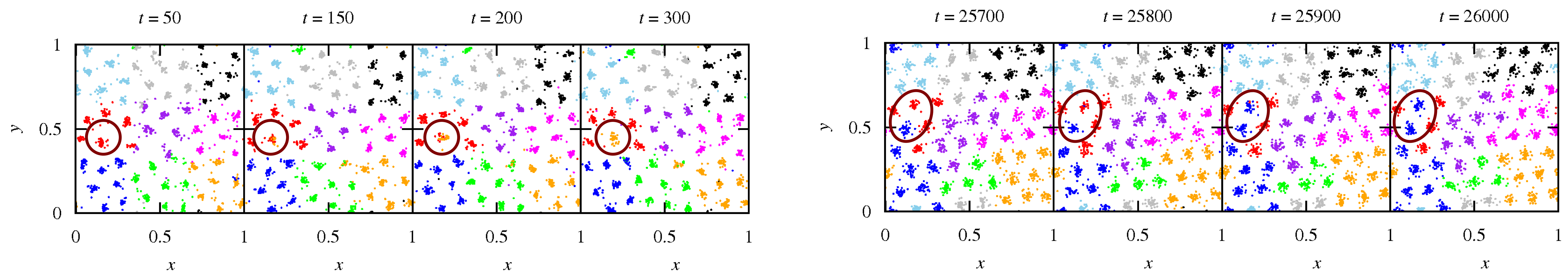


Time evolution of the system with **Lévy jumps** for different values of generalized diffusion coefficient $\varkappa_\mu$ and Lévy index μ; top: $\varkappa_\mu = 10^{-4}$; bottom: $\varkappa_\mu = 5 \cdot 10^{-5}$; left: $\mu = 1.3$; right: $\mu = 1.7$.



↙ Left: systems with **Lévy** jumps; right: systems with **Gaussian** jumps. ↘

mixing of clusters due to inter-cluster traveling: $\mu = 1.5$, $\varkappa_\mu = 5 \cdot 10^{-5}$ (for system with Lévy jumps); $\varkappa = 2 \cdot 10^{-5}$ (for system with Gaussian jumps).



appearance of a new cluster: $\mu = 1.3$, $\varkappa_\mu = 5 \cdot 10^{-5}$, $R = 0.1$ (for system with Lévy jumps); $\varkappa = 10^{-5}$, $R = 0.15$ (for system with Gaussian jumps).