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Novel decay laws for the one-dimensional reaction - diffusion model $A + A \to (2 - \epsilon)A$ as consequence of initial distributions

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Abstract

The effect of the initial particle distribution on the one-dimensional coagulation $(\epsilon = 1)$ *and annihilation* $(\epsilon = 2)$ *reaction - diffusion models is studied analytically. With this aim, an exact expression for the particle number, N(t), given explicitly in terms of the initial particle distribution, is derived. It is found that if the initial distribution has divergent first moments new decay laws occur. For the case of fractal distributions of dimension* γ *we obtain exactly the mean relative number of particles,* $n(t) = \langle N(t) \rangle / \langle N(0) \rangle$*. For long times it evolves as* $n(t) \sim c_1 \tau^{-\gamma/2} + c_2 \tau^{-1/2} + c_3 \tau^{-\gamma/2-1/2}$*, with* $\tau = 2Dt$*. The existence of non-fractal initial distributions that lead to new decays is also discussed. As examples are considered an interparticle probability distribution of the form* $p(r) \sim r^{-2}$ *which yields* $n(t) \sim a_1 \tau^{-1/2} \ln(\tau) + a_2 \tau^{-1/2}$ *and a family of distributions of the form* $p(r) \sim r^{-1}[\ln(r/r_0)]^{-1-\alpha}$*, with* $\alpha > 0$*, which yields* $n(t) \sim [\ln(\tau)]^{-\alpha}$*. These results are tested by Monte Carlo simulations.*

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