**Single species annihilation**

Simulations of a single-species annihilation reaction on hypercubic lattices as a function of the lattice spatial dimension $d.$

Consider lattice dimensions $d\leq 3$, and choose a lattice size$ L$ large enough (such that the results do not depend on $L$). For $d=2, 3$ hypercubic lattices. Apply periodic boundary conditions in all lattice directions. Introduce the lattice site occupation variable

$$ρ\left(x,t\right)=1, if x is occupied 0, if x is empty $$

 Assume $ρ\left(x,t=0\right)=1, $for all $x$**.**

Simulation approach 1

At each time step $Δt$

1. Choose one lattice site randomly
2. A) If the chosen lattice site is occupied by a particle ($ρ=1$ on that site), that particle performs one random jump to one of the neighboring lattice sites with the probabilities

$$p=\frac{1}{2} in d=1 , \frac{1}{4} in d=2, \frac{1}{8} in d=3 $$

If the new position is occupied, annihilate both particles (set $ρ=0$ on the sites from where the particle started and ended). If the new position is empty, the particle stops at the new position. Go to item #3 below.

B) If the chosen lattice site is empty, do nothing and go to item #3 below.

1. Update time $t\_{n+1 }=t\_{n}+Δt$

Plot the average (over many simulations with different seeds for the random number generator) number density $ρ\left(t\right)=\frac{N\\_occupied\left(t\right)}{L^{d}}$ as a function of time for $d=1, 2, 3$. In this approach $Δt∝\frac{1}{L^{d}}.$

Simulation approach 2, “rejection free”

A randomly chosen lattice site must be occupied. All the other steps are as above. For this you will need at each time a list of occupied lattice sites (keep in mind that the list is time-dependent).

In this approach the time step $Δt\left(t\right)∝\frac{1}{ρ\left(t\right)}\frac{1}{L^{d}}=\frac{L^{d}}{N\_{occupied}\left(t\right)}\frac{1}{L^{d}}=\frac{1}{N\_{occupied}\left(t\right)} $.

Plot the average number density $ρ\left(t\right)=\frac{N\\_occupied\left(t\right)}{L^{d}}$ as a function of time for $d=1, 2, 3.$