Diffusion Limited Reactions: Nearest Neighbor Distances at a Trap

Haim Taitelbaum,[1] Shlomo Havlin,[1] George H. Weiss,[2] and Raoul Kopelman[3]

1. Department of Physics, Bar-Ilan University, Ramat-Gan, Israel
2. Physical Sciences Laboratory, NIH, Bethesda, MD 20892, USA
3. Department of Chemistry, University of Michigan, Ann Arbor, MI 48109, USA

The phenomenon of self-organization of reacting systems in low dimensions has attracted much attention recently. One characterization of the tendency to self-organize is to study the distribution of the distance of the closest diffusing particle to a single trap, which is allowed to be perfect or imperfect.

For perfect trap in one dimension, the asymptotic density of the nearest-neighbor distance is found to be a time-dependent skewed-Gaussian function, and the mean value of this distance increases asymptotically as $t^{1/4}$. The general case of imperfect trap is modelled in terms of the radiation boundary condition. Our exact solution for this case permits one tp follow the transition in the shape of the probability density from the time dependent skewed Gaussian for perfect reaction, to the time independent exponential corresponding to total reflection in one dimension.

Similar results are given for the case of a reactive sphere in the presence of mobile particles in three dimensions.

How do the results for one dimension change when the diffusing particles are subject to a certain potential? We study three models of possible potentials, using analytical and numerical methods:

1) Hard-Core interaction between the diffusing particles.

2) External field - Biassed diffusion.

3) Local random fields along the one-dimensional chain.