Dynamics of tagged particles in a biased A + A → Ø system in one dimension: result for asynchronous and parallel updates

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Dynamical features of tagged particles are studied in one dimensional A + A →Φ system on a periodic lattice, where the particles A have a bias ε to move towards its nearest neighbouring particle and two particles are annihilated on contact.

For asynchronous dynamics, at each update a site is selected randomly and if there is a particle on it, it makes a movement. The fraction of walkers $\rho(t)$ at time t was found to decay as $\rho(t) \sim t^a$, with a=-1 when the bias, however small, is introduced. In the absence of the bias, it is known that a = 1/2, which suggests that in the presence of the bias, the walkers, in the long time limit, behave as ballistic walkers [1-3]. To get a better understanding we study the dynamics of a tracer walker in the biased case specifically to check whether they perform ballistic motion or not.

We show that for $\varepsilon > 0$, probability distribution of the particles π (x, t) shows a double peak structure with a dip at x = 0 and at late time regime it assumes a double delta form. For any ε, there is a time scale t* which demarcates the dynamics of the particles. Below t*, the dynamics are governed by the annihilation of the particles and the particle motions are highly correlated, while for t>> t*, the particles move as independent biased walkers. t* diverges at $\varepsilon = 0.5$ which is the critical point of the dynamics. At $\varepsilon=0.5$, the probability S(t), that a walker changes its direction of motion at time t, decays as $S(t) \sim t^a$ with a=-1, and the distribution $D(\tau)$ of the time interval τ between consecutive changes in the direction of a typical walker decays with a power law as $D(\tau) \approx \tau^a$ with a=-2. When the system is updated using parallel dynamics, all the particles are updated simultaneously. If the particles are found to occupy same site after the completion of a single MC step, then both of them are annihilated. $\pi(x,t)$ shows a non Gaussian single peaked structure and the scaling variable is different from the usual random walker case. Here, the fraction of surviving particle $\rho(t)$ shows a unsual (a ln t/t) behaviour. For $\varepsilon = 0.5$, a pair of neighbouring particles, termed as dimers, can survive indefinitely in the system which is exclusive for parallel dynamics only.

When the bias ε becomes negative, $\pi(x,t)$ retain its Gaussian nature as for $\varepsilon = 0$; however, the scaling factor is ε dependent. Finally, a comparative analysis for the behaviour of all the relevant quantities for the system using parallel and asynchronous dynamics shows that there are significant differences for $\varepsilon > 0$ while the results are qualitatively similar for $\varepsilon < 0$.

References

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