Investigating the Origin of the Non-uniform Phase in a Bosonic Rydberg System

Suvechha Indu[1, *] and Raka Dasgupta[1, †]

[1]*Department of Physics, University of Calcutta,* 92 *A. P. C. Road, Kolkata* 700009*, India*

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We have studied a two-level dissipative non-equilibrium bosonic Rydberg system in an optical lattice. We have described the system in terms of the collective behaviour of the atoms occupied in a single site. We have got the dynamical equations for the system with the help of the master equation and taking the mean filed approximation. Three different phases are found in terms of the Rydberg population across the sublattices: the uniform phase, the antiferromagnetic phase and the oscillatory phase. Then, we have proposed an order parameter to characterize those phases and plot it with the on-site interaction parameter, keeping all other parameters fixed. The origin of these three phases can be explained by exploring the stability of the fixed points of the system and also by studying the spatial correlation by semi-classical Monte Carlo simulation. Two types of fixed points are found for the system: three branches of the uniform fixed points and two branches of the non-uniform fixed points. The uniform phase comes from one stable branch of the uniform fixed points, and the antiferromagnetic phase comes from two stable branches of the non-uniform fixed points, here, one branch of the uniform fixed points is present, but it is unstable. In the oscillatory region, there are no stable fixed points, so population imbalance fluctuates a lot. We have studied the spatial correlation between two sites and have plotted the correlation with site differences for the three phases. We have found that the order of the correlation is different in the three different phases. The correlation is maximum in the antiferromagnetic phase and minimum in the uniform phase. The zigzag pattern of the correlation in the antiferromagnetic and the oscillatory phases shows that there is a positive correlation for even site difference and a negative correlation for odd site difference.

* suvechhaindu@gmail.com

† rdphy@caluniv.ac.in

[1] **Different Phases in A Two Level Dissipative Bosonic System with Rydberg Atoms,** S. Indu, R. Dasgupta, Manuscript under preparation.

[2] **Lee, T. E., HÃ€ffner, H.,and Cross, M. C. (2011). Antiferromagneticphase transition in a nonequilibriumlattice of Rydbergatoms.Physical Review A,84(3), 031402**