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Self organisation and metastability of cavity bosons at very long times, beyond the adiabatic elimination approximation

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Phase-space formulations of quantum mechanics like the positive-P and truncated Wigner can give access to the full quantum behaviour of very large systems. In particular, the full distribution of single-shot configurations can be obtained from a stochastic simulation. This is particularly useful for dissipative systems for which direct simulation is harder but phase space methods become stable [1].

In a recent work [2] we have looked at the very long-time behaviour and self-organisation of weakly interacting bosons in a 2d optical lattice coupled to a lossy cavity, in the regime of high filling similar to experiments at ETH. The truncated Wigner representation allows us to go orders of magnitude longer in time compared to earlier numerical work. It takes into account the dynamics and correlation of the cavity mode, quantum fluctuations, and self-organization of individual runs. We observe metastability at very long times and superfluid quasi-long range order, in sharp contrast with the true long range order found in the ground state of the Bose-Hubbard model with extended interactions obtained by adiabatically eliminating the cavity. The metastability appears to be dependent on the relaxation of the adiabatic elimination constraint. As the strength of the cavity coupling increases in a superfluid, the system first becomes (lattice) supersolid at the superradiant transition and then turns into a charge-density wave via the BKT mechanism. Notably, experimental preparation times have often been comparable with the very long times simulated here, so the metastable effects may be relevant in practice.

References

[1] G. Orso, J. Zakrzewski, P. Deuar, Self-organized cavity bosons beyond the adiabatic elimination approximation, arXiv:2312.10502
[2] P. Deuar, A. Ferrier, M. Matuszewski, G. Orso, M. H. Szymanska, Fully quantum scalable description of driven-dissipative lattice models, PRX Quantum 2, 010319 (2021)

Short bio (50 words) or link to website

http://info.ifpan.edu.pl/~deuar/people.html

Relevant publications (optional)

G. Orso, J. Zakrzewski, P. Deuar,
Self-organized cavity bosons beyond the adiabatic elimination approximation, arXiv:2312.10502
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P. Deuar, A. Ferrier, M. Matuszewski, G. Orso, M. H. Szymanska,
Fully quantum scalable description of driven-dissipative lattice models,
PRX Quantum 2, 010319 (2021)
http://dx.doi.org/10.1103/PRXQuantum.2.010319

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