



THE CHINESE UNIVERSITY OF HONG KONG
Department of Physics
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**Quantum phase transitions in the Dicke model:
Numerically exact study**

by

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ALL INTERESTED ARE WELCOME

Abstract

By using extended bosonic coherent states, a new technique to solve the Dicke model exactly is proposed in the numerical sense. The accessible system size is two orders of magnitude higher than that reported in literature. Finite-size scaling for several observables, such as the ground-state energy, Berry phase, fidelity, order parameter, and concurrence are analyzed and corresponding exponents are obtained. Some existing discrepancy in the literature are reconciled [1,2].

The instability, so-called the quantum-phase-like transition (first-order), in the Dicke model with a rotating-wave approximation for finite N atoms is investigated in terms of the Berry phase and the fidelity. It can be identified by the discontinuity of these quantities as a function of the atom-field coupling parameter. Involving an additional field A^2 term, it is observed [3] that the instability is not eliminated even for strong interaction of the bosonic fields, contrarily to the previous studies.

We also study the dipole-coupled two-level atoms (qubits) in a single-mode resonant cavity. For finite system, it is observed the quantum phase transition is of the first-order. In the thermodynamic limit, a second-order quantum phase transition occurs. Finite-size scaling for several observables, such as the ground-state energy, the average fidelity susceptibility, and concurrence are performed. The obtained scaling exponents suggest that the interaction of two-level atoms does not change universality.

The possible extensions to the spin-boson model and (Hubbard)-Holstein model are also given.

1. Qing-Hu Chen, Yu-Yu Zhang, Tao Liu, and Kelin Wang, Phys. Rev. A 78, 051801(2008), Rapid communication.
2. Tao Liu, Yu-Yu Zhang, Qing-Hu Chen*, Kelin Wang, Phys. Rev. A 80, 023810(2009).
3. Yu-Yu Zhang, Tao Liu, Qing-Hu Chen*, Kelin Wang, arXiv: 0901.2705, Submitted to EPL.

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