185.
Accession number:20113614301960
Title:Superradiance, Berry phase, photon phase diffusion, and number squeezed state in the U(1) Dicke (Tavis-Cummings) model
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Source title:Physical Review A - Atomic, Molecular, and Optical Physics
Abbreviated source title:Phys Rev A
Volume:84
Issue:2
Issue date:August 25, 2011
Publication year:2011
Article number:023840
Language:English
ISSN:10502947
E-ISSN:10941622
CODEN:PLRAAN
Document type:Journal article (JA)
Publisher:American Physical Society, One Physics Ellipse, College Park, MD 20740-3844, United States
Abstract:Recently, strong-coupling regimes of superconducting qubits or quantum dots inside a microwave circuit cavity and BEC atoms inside an optical cavity were achieved experimentally. The strong-coupling regimes in these systems were described by the Dicke model. Here, we solve the Dicke model by a 1/N expansion. In the normal state, we find a √N behavior of the collective Rabi splitting. In the superradiant phase, we identify an important Berry phase term that has dramatic effects on both the ground state and the excitation spectra of the strongly interacting system. The single photon excitation spectrum has a low-energy quantum phase diffusion mode in imaginary time with a large spectral weight and also a high-energy optical mode with a low spectral weight. The photons are in a number squeezed state that may have wide applications in high sensitive measurements and quantum-information processing. Comparisons with exact diagonalization studies are made. Possible experimental schemes to realize the superradiant phase are briefly discussed. © 2011 American Physical Society.