Masao Hirokawa (Hiroshima)

Quantum simulation of interaction between atom and light

Abstract

At the dawn of the 21st century, the solid-state analogue of the interaction between atom and light in a superconducting system was theoretically proposed by Yu. Makhilin, G. Schön, and A. Shnirman [Rev. Mod. Phys. 73 (2001) 357] and by F. Marquardt and C. Bruder [Phys. Rev. B 63 (2001) 054514]. It has been experimentally demonstrated by I. Chiorescu, et al. [Nature 431 (2004) 159] and by A. Wallraff, et al. [Nature 431 (2004) 162]. In that solid-state analogue, an artificial atom and a microwave are used respectively for the atom and the light. The interaction is made near a microwave resonator on a superconducting circuit. Here, the artificial atom is made by using a superconducting LC circuit. The harmonic oscillator atom is obtained in the case without any Josephson junction, and the 2-level atom is based on the anharmonicity coming from Josephson junctions. Their current cutting-edge technology is beginning to show us the ultra-strong coupling regime or the deep-strong coupling regime of the atom-light interaction beyond its standard regime of quantum electrodynamics, which is even equal to that of quantum chromodynamics. For instance, F. Yoshihara, et al. have demonstrated around 100% of the atom-light interaction in their experiment [Nature Physics 13 (2017) 44]. I would like to introduce the following subjects on quantum simulation using the artificial atom on the superconducting circuit. I chiefly talk about

1) the duality between a dark state and a quasi-dark state for an artificial atom coupled to both the photon and phonon fields in an optomechanical system. In addition to this, if we have time, I also talk about

2) the dressed photon and the Schrödinger-cat-like entangled ground state of the general quantum Rabi model; and

3) the possibility of the conversion from virtual photon to real photon in a ground state of that model.

1. The Rabi model gives off a flavor of spontaneous SUSY breaking" M. Hirokawa Quantum Studies: Mathematics and Foundations 2: 379-388 (2015)

2. Duality between A Dark State And A Quasi-Dark State" M. Hirokawa Annals of Physics (N.Y.) 377: 229-242 (2017)

3. A Mathematical Analysis of Dressed Photon in Ground State of Generalized Quantum Rabi Model Using Pair Theory" M. Hirokawa, J. Møller and I. Sasaki Journal of Physics A: Mathematical and Theoretical 50: 184003 (2017)