Quantum State Manipulations in Hybrid Quantum Optical Systems

L Yuan[1]

[1]*School of Physics and Astronomy, Shanghai Jiao Tong University, Shanghai, China*
Contact Email: yuanluqi@sjtu.edu.cn

It is of fundamental interest in exploring the photon-matter interactions in various quantum optical systems, which may provide many novel ways of manipulating photons and preparing quantum states, and hence leads to great importance in quantum information. This talk will focus on several interesting hybrid quantum optical platforms. I firstly will talk about our recent work on seeking the possibility of creating arbitrary synthetic dimensions *via* multi-photon dynamics on a one-dimensional lattice, where the one-dimensional lattice hosting N indistinguishable photons can be mapped to a single photon on a N-dimensional lattice with high symmetry [1]. Next, I will discuss a single-photon transport problem in a system where a giant atom is coupled with resonator arrays under dynamic modulations. We find a way to convert propagating photon into localized state, together with the time of the photon-atom interaction lasting longer than the coupling rate between the atom and the resonator [2,3]. Moreover, our model points out a way to study the light-atom interaction in a synthetic frequency dimension, which has triggered great interest very recently in the photonic society but has never been considered for the photon-atom interaction in the quantum-optics society. Lastly, I will show a non-Hermitian atom-waveguide system, creating a lattice model including nonreciprocal long-range hoppings through chiral-waveguide photon-mediated interactions. We further demonstrate the subradiant non-Hermitian skin effect but extended superradiant modes in this system. Our works can hopefully trigger more potential in manipulating quantum optical states.

References

[1] P-Y Chang, J-S You, X Wen and S Ryu, Phys. Rev. Res. **3**, 033069 (2021)

[2] H Xiao, L Wang, Z Li, X Chen and L Yuan, npj Quantum Inf., in print

[3] H Xiao, L Wang, Z Li, X Chen and L Yuan, arXiv:2111.06764 (2021)