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Quantum simulation of (1+1) D U (1) lattice gauge-Higgs model by using cold atoms in one-dimensional optical lattice

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Recently atomic quantum simulation for high-energy physics comes to become an active field in cold-atom physics society. In particular there are a plethora of proposals to build up a quantum simulator for lattice gauge theory by using cold atoms in an optical lattice. To realize the quantum simulator for lattice gauge theory, theoretical proposal for future experiment is important. In this talk, we show theoretically an atomic quantum simulator of U lattice gauge-Higgs model based on an extended Bose-Hubbard model in one dimensional (1D) optical lattice. This quantum simulator of the lattice gauge theory is directly connected towards the Bose-Hubbard model with nearest-neighbor (NN) interactions. In the 1D system the most important ingredient, i.e., Gauss' law can be implemented in a much simple way, i.e., only controlling the NN interactions. Furthermore we show a global phase diagram. Also by using the correspondence between the Bose Hubbard model and the lattice gauge theory we interpret these phases from the view of the lattice gauge theory. In addition, it is important and interesting to detect the non-equilibrium properties of the quantum simulator. We focus on simulating the dynamics of an electric flux (confinement string) in both Higgs and confinement phase. To study this subject we use the Gross-Pitaevskii equation for the Higgs (superfluid) regime and the semi-truncated Wigner method for shallow confinement regime. We certify that the electric flux spontaneously breaks in the Higgs phase on the other hand in the shallow confinement regime the electric flux is dynamically stable. These results are expected to be measured in future real experiments. Moreover our numerical simulations find that the Schwinger-like mechanism which can be observed. Electric fields oscillate via a Higgs and anti-Higgs pair creation.

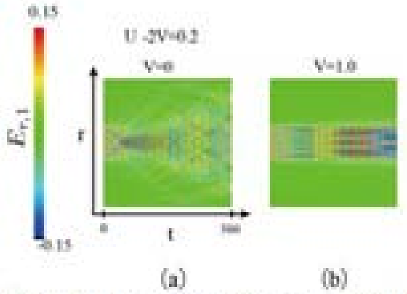

Fig: Real time-dynamics of a single electric flux. (a) In Higgs regime, the initial electric flux gradually spreads out. (b) In confinement regime, the shape of the initial electric flux is kept. The electric field oscillates changing their sign. This phenomenon is explained by the string-antistring oscillation that is also observed in the QED real-time dynamics

Biography

Yoshihito Kuno is Postdoctoral Fellow of Japan Society for the Promotion of Science (JSPS), and a Member of Quantum Optics Group of Kyoto University, Japan. He got his PhD at Nagoya Institute of Technology.

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