Higher-order topological Peierls insulator in a two-dimensional atom-cavity system

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In this work, we investigate a two-dimensional system of ultracold bosonic atoms inside an optical cavity, and show how photon-mediated interactions give rise to a plaquette-ordered bond pattern in the atomic ground state [1]. The latter corresponds to a 2D Peierls transition, generalizing the spontaneous bond dimmerization driven by phonon-electron interactions in the 1D Su-Schrieffer-Heeger (SSH) model. Here the bosonic nature of the atoms plays a crucial role to generate the phase, as similar generalizations with fermionic matter do not lead to a plaquette structure. Similar to the SSH model, we show how this pattern opens a non-trivial topological gap in 2D, resulting in a higher order topological phase hosting corner states, that we characterize by means of a many-body topological invariant and through its entanglement structure. Finally, we demonstrate how this higher-order topological Peierls insulator can be readily prepared in atomic experiments through adiabatic protocols. Our work thus shows how atomic quantum simulators can be harnessed to investigate novel strongly-correlated topological phenomena beyond those observed in natural materials.

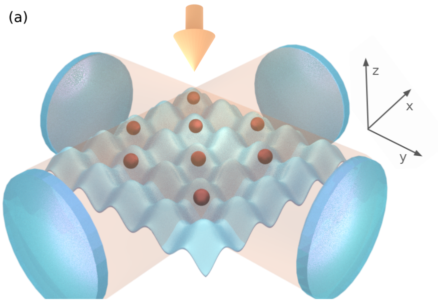

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Fig. 1: Atom-cavity experimental setup: (a) Ultracold bosonic atoms are trapped in the lowest band of a 2D optical lattice. The atoms are coupled to two cavity modes created by two optical cavities aligned in the x and y directions, and to a laser pump aligned in the z direction.

References

[1] Joana Fraxanet, Alexandre Dauphin, Maciej Lewenstein, Luca Barbiero, Daniel González-Cuadra, Phys. Rev. Let. (in press), arXiv:2305.03409 (2023)