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Topological holographic quench dynamics in synthetic frequency space

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Characterization the equilibrium topological invariants through the dynamics quench process attracts extensive interests very recently. Usually, the characterization of non-equilibrium topological invariants shown during the dynamics quench requires information in both the time and spatial dimensions. We propose the topological holographic quench dynamics in synthetic dimension to characterize photonic topological phases. We use ring resonators to construct a pseudo spin model in the synthetic frequency dimension. The quench dynamics is triggered by initializing a trivial state which evolves under a topological Hamiltonian. Our key result is that the complete topological invariance of the Hamiltonian contained in quench dynamics can be directly demonstrated solely using the information along the time dimension. In particular, two time scale are shown during the dynamical evolution, with one time scale mimicking the Bloch momentum dimension and the other mimicking the time evolution of the state. Hence, the quench dynamic is reconstructed in the two time scales, and the non-equilibrium topological invariants is obtained by using the information on the band inversion surfaces (BIS). Therefore, a universal correspondence between the quench dynamics and the equilibrium topological invariance of the spin model is obtained through utilizing the evolution of the field in the modulated ring resonators solely along the time dimension in simulations. This work shows that photonics synthetic frequency dimension can be used to study the topological non-equilibrium dynamics through quench dynamics [Light. Sci. Appl. 10, 209 (2021)].

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