Quantum geometry, Optical property, and Energy gap

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## Abstract

Insulating state with finite energy gap is ubiquitous. It is well known that they are not all equivalent --- they can be distinguished by the topology of their ground state wavefunction. The nontrivial topology leads to interesting physics including quantized Hall conductance. Recent study is further revealing the importance of quantum geometry underlying the topology, and the consequence of it has been intensively studied. On the other hand, despite of its fundamental nature of topological ground state, the energy gap has not been paid much attention in relation to topology and geometry.

In this talk, I would like to ask the following question: “Is there a limit on energy gap for a ground state with nontrivial topology or geometry?” We answer this question affirmatively. Using a simple argument on optical responses, we derive a number of relations between the ground state property and energy gap, including a tight upper bound on energy gap for Chern insulators [1,2,3]. Our theory applies to any insulating systems, including strongly correlated systems such as Mott insulators and fractional quantum Hall systems. Our theory also reveals offers a powerful tool to understand quantum materials from both theory and experiments [4].

[1] Yugo Onishi and Liang Fu, “Fundamental bound on topological gap.” arXiv:2306.00078. Accepted to Phys. Rev. X.

[2] Yugo Onishi and Liang Fu, “Universal relation between energy gap and dielectric constant.” arXiv:2401.04180.

[3] Barun Ghosh, Yugo Onishi, Su-Yang Xu, Hsin Lin, Liang Fu, and Arun Bansil, “Probing quantum geometry through optical conductivity and magnetic circular dichroism.” arXiv:2401.09689.

[4] Yugo Onishi and Liang Fu, “Quantum weight.” arXiv:2401.13847.