# Quantum Metric Lengths and Quantum Metric Localization

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In most solid state systems, the Fermi velocity combined with energy gives rise to many important length scales such as the coherence length and the superconducting coherence length. As Fermi velocity goes to (nearly) zero in flat band materials, these conventional length scales vanish. The question is: in flat band materials, what gives rise to the important length scales?

In this talk, we show that the quantum metric length, which was known to determine the size of the optimally localized Wannier functions, is indeed the fundamentally important length scale in flat band materials. We show that, while the quantum metric length can be exceedingly long, it determines the superconducting coherence length of flat band superconductors [1,2], the coherence length of a flat band Josephson junction [3], the decay length of Majorana modes in flat band topological superconductors [4] and more. The critical current anomaly had been observed experimentally in flat band Josephson junction which can be explained by quantum metric contributions [5].

Recently, we show that the quantum metric length determines the localization length of disorder flat band materials. Take a 1D system with a flat band (with a small dispersion ) as an example. As disorder increases, the localization length decreases as expected from Anderson localization. However, as disorder further increases, the localization length reaches a plateau where the localization length is twice the quantum metric length. The plateau is extremely wide for an isolated flat band. We call this regime where the localization length is governed by the quantum metric length, the quantum metric localization regime [6].

References:

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