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One dimensional topological pump induced by dynamics of moiré pattern

We theoretically study the charge transport induced by a motion of moiré pattern in a relative translation of overlapped crystals. In recent years, there have been remarkable advances in fabrication of atomically thin materials[1], and the technology enables to stack different two-dimensional materials on top of each other in arbitrary twist angles. The interaction between the rotationally stacked layers have a crucial impact on the physical properties of the system, and even the superconductivity and correlated insulating states are realized in the twisted bilayer graphenes.[1] These emergent properties are actually caused by the existence of the moiré interference pattern, which is generated by the slight lattice mismatch of the stacked layers.

While so far most of theoretical and experimental studies on the twisted moiré superlattices are limited to the static systems, here we consider dynamical properties in *moving* moiré pattern. We consider a situation where one layer of the twist bilayer is slid with respect to the other layer [Fig. 1(a)]. Then a translation of an atom scale (~ a few Å) leads to a shift of the moiré pattern with much larger length scale (~ a few 10 nm), and it is known as “the moiré speed up”. We expect the moving of the moiré pattern should cause the electronic transport, and it should be explained in terms of the topological pumping in the time-periodic Hamiltonian[2].

In order to investigate the principle of the moiré pumping, here we consider a simplified one-dimensional double chain model [Fig. 1(b)], where a pair of tight-binding chains with different periodicities are coupled by the inter-chain electron hopping. We calculate the charge pumping caused by a relative translation of the chains using the adiabatic formalism. We show that the electrons are actually conveyed by the moving moiré pattern, where the charge transfer can be described by the topological Chern number analogous to the quantum Hall effect. [3] We also extend the analysis to the two-dimensional moiré superlattices.

References

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[2] D, J. Thouless, Pyhs. Rev. B, **27** (1983) 6083
[3] D, J. Thouless, M. Kohmoto, M. P. Nightingale, M. den Nijs, Pyhs. Rev. Lett, **49**, (1983) 6083

Figures

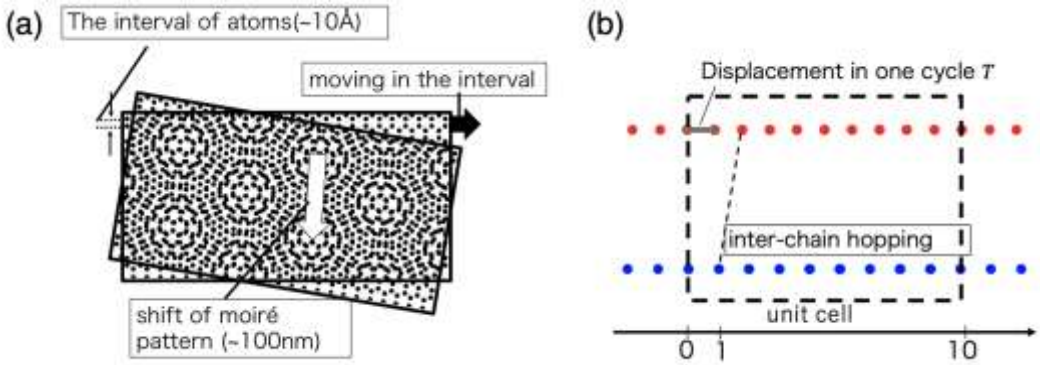

Figure 1(a): Schematic picture of the moiré pumping in relative sliding of the twisted bilayer.
Figure 1(b): One-dimensional double chain model.