Orbital Hall effect as an alternative to valley Hall effect in gapped graphene

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Gapped graphene has been proposed to be a good platform to observe the valley Hall effect, a transport phenomenon involving the flow of electrons that are characterized by different valley indices. In the present work, we show that this phenomenon is better described as an instance of the orbital Hall effect (OHE), where the ambiguous "valley" indices are replaced by a physical quantity, the orbital magnetic moment, which can be defined uniformly over the entire Brillouin zone. This description removes the arbitrariness in the choice of arbitrary cutoff for the valley-restricted integrals in the valley Hall conductivity, as the conductivity in the OHE is now defined as the Brillouin zone integral of a new quantity, called the orbital Berry curvature. This reformulation in terms of OHE provides a direct explanation to the accumulated opposite orbital moments at the edges of the sample, observed in previous Kerr rotation measurements.

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