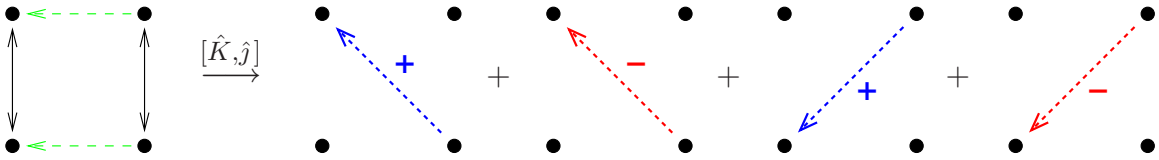

Figure 4.10: Commutator of kinetic energy and paramagnetic current: in a hypercubic lattice, contributions of the form Fig. 4.9 b cancel in summations over square loops.

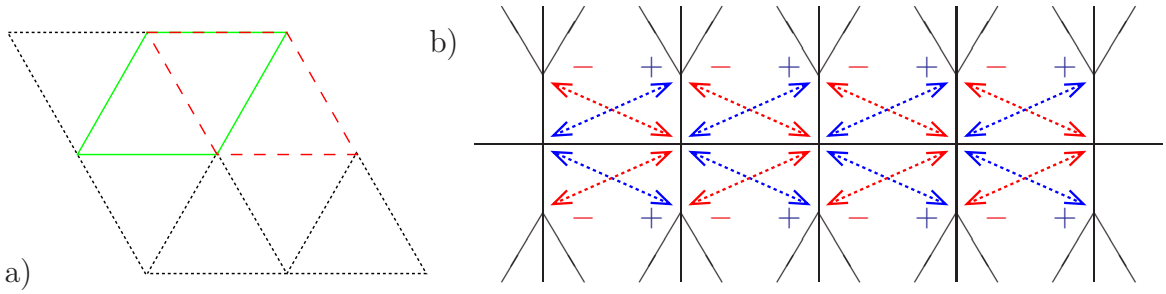

Figure 4.11: a) Sums over parallelogram loops (solid lines, dashed lines) lead to a cancellation of all contributions of $[\hat{K},\hat{\jmath}]$ in an fcc lattice. **b)** Nonvanishing full commutator $[\hat{K},\hat{\jmath}]$ (dotted arrows) for the Bethe lattice.

the existence of loops of length four as shown in Fig. 4.10 is a necessary condition for the absence of absorption in the noninteracting limit. Note that with suitable modifications (allowing for several current chains) the present discussion generally applies to regular Bravais lattices.[39] Then, the loops along which the commutator cancels consist of pairs of parallel edges as indicated for the case of the fcc lattice in Fig. 4.11 a. Obviously, the properties of a Bravais lattice guarantee that each pair of hopping bonds associated with a common lattice site can be closed to such a parallelogram. Thus, the real-space argument leads to the same result for Bravais lattices as the $\boldsymbol{k}$-space derivation in subsection 4.1.4: the reduction of $\sigma(\omega)$ to a Drude peak in the noninteracting limit.

In contrast, the failure of coherence in the present view on the Bethe lattice can be unambiguously attributed to the nonvanishing terms in the commutator of kinetic energy and current operator represented in Fig. 4.11 b.

4.4.3 Periodically Stacked Lattices

In this subsection, we will leave behind approaches for computing $\sigma(\omega)$ strictly for the Bethe lattice and instead discuss a very general concept which can be used for establishing expressions for the conductivity for one particular current direction in the limit of $Z \to \infty$. While this method can be applied to any underlying lattice

[39] The restriction to lattices of the Bravais type is necessary; in fact, our argument correctly implies that absorption at finite frequencies takes place for lattices with several atoms per unit cell even in the noninteracting limit just like for the Bethe lattice.