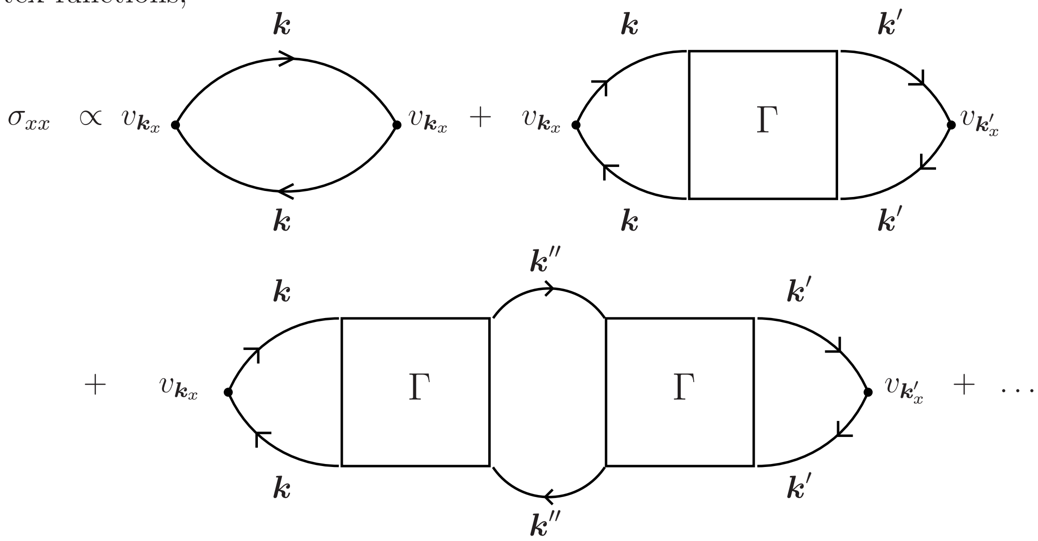
4.3 Optical Conductivity in the Limit $d \to \infty$

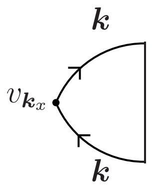
In this section, we will initially follow the conventional treatment used for the derivation of $\sigma(\omega)$ for the hypercubic lattice with NN hopping for $d \to \infty$ (Pruschke et al., 1993), but keep the treatment general for a single-band model defined on a lattice which is periodic and exhibits inversion symmetry in current direction x.[19] In this case, (4.49) implies for the paramagnetic contribution to the optical conductivity[20]

$$\sigma_{xx}(\omega) = \frac{ie^2}{V\hbar^2(\omega + i0^+)} \sum_{\boldsymbol{k},\boldsymbol{k}'} \sum_{\sigma\sigma'} v_{\boldsymbol{k}_x} v_{\boldsymbol{k}'_x} \langle\langle \hat{n}_{\boldsymbol{k}\sigma}, \hat{n}_{\boldsymbol{k}'\sigma'} \rangle\rangle (\omega + i0^+) \,. \tag{4.60}$$

For simplicity, we have here introduced the notation $v_{\boldsymbol{k}_x}$ for the x component of the vector $\boldsymbol{v}_{\boldsymbol{k}}$. In a diagrammatic series expansion, the correlation function can be expressed in terms of interacting Green function lines and particle-hole irreducible vertex functions,



The particle-hole irreducible vertex function Γ becomes effectively local in $d \to \infty$, i.e., becomes independent of $\boldsymbol{k}$, $\boldsymbol{k}'$. Thus, the summations over $\boldsymbol{k}$, $\boldsymbol{k}'$ can be performed independently (Khurana, 1990; Pruschke et al., 1993; Georges et al., 1996). Furthermore, the dispersion has even parity with respect to k_x, i.e., $\epsilon_{(-k_x,\boldsymbol{k}_\perp)} = \epsilon_{(k_x,\boldsymbol{k}_\perp)}$. Therefore, $G_{\boldsymbol{k}\sigma}(\omega) = 1/(\omega - \epsilon_{\boldsymbol{k}} - \Sigma_\sigma(\omega))$ also has even parity while $v_{\boldsymbol{k}_x}$ has odd parity with respect to k_x. Consequently, each individual $\boldsymbol{k}$ summation involving only one current vertex $v_{\boldsymbol{k}_x}$ vanishes:



$= 0$.

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[19] For lattices which are not periodic in all directions, one would have to use the replacement $\boldsymbol{k} \to (\epsilon, k_x)$ in the following. Thus, we would label eigenstates of the noninteracting system by their momentum in current direction and total energy instead of the full momentum.

[20] Here, the diamagnetic contribution is neglected so that resulting expressions will be complete only for $\mathrm{Re}\,\sigma(\omega)$ for $\omega \neq 0$.