## 5.3 Particle and energy current

As often used before each volume element $dk$ contains

$$2\frac{d^3k}{(2\pi)^3} \tag{5.19}$$

electronic states which are occupied with

$$dn = \frac{d^3k}{4\pi^3} f(\vec{r}, \vec{k}) \tag{5.20}$$

particles. The complete current density is therefor

$$\vec{j} = \frac{q}{4\pi^3} \int_{V_k} \vec{v}(\vec{k}) f(\vec{r}, \vec{k}) d^3k = \frac{q}{4\pi^3} \int_{V_k} \vec{v}(\vec{k}) f^{(1)}(\vec{r}, \vec{k}) d^3k \qquad . \tag{5.21}$$

Here we used

$$\int_{V_k} \vec{v}(\vec{k}) f_0(\vec{r}, \vec{k}) d^3k = 0 \tag{5.22}$$

since $f_0(\vec{r}, \vec{k})$ is a symmetric function in $\vec{k}$, $\vec{v}$ an antisymmetric function in $\vec{k}$ and we integrate over symmetric boundaries (In equilibrium no currents are flowing!). Correspondingly we find for the energy flux density:

$$W = \frac{1}{4\pi^3} \int_{V_k} E(\vec{k}) \vec{v}(\vec{k}) f^{(1)}(\vec{r}, \vec{k}) d^3k \qquad . \tag{5.23}$$