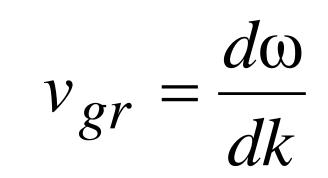
#### Dynamics of Electrons in a Crystal Lattice

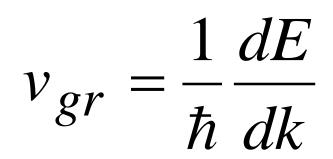
- we defined a particle as a wave packet
- the uncertainty relation for k and x:  $\Delta k \cdot \Delta x \sim 1$
- an electron is localized within the region  $\Delta x \sim 1/\Delta k$
- The ψ function of the electron can be represented in the form of the sum of plane waves of the kind eikr, which values of wave numbers are within the limits of Δk

• $\Delta k$  is not great, and the superposition of the plane waves forms a wave packet



# the velocity of an electron in a crystal

•  $V_{gr}$  is the velocity of the electron in a crystal. Taking into consideration the equation for energy  $E = \hbar \omega$ , we find this velocity



# work

 an electric field is imposed on a crystal, apart from the forces of crystalline lattice F crystal, the electron experiences the electric force F = eE. During the time *dt* this force does the work  $dA = Fv_{gr} dt$  on the electron

$$dA = \frac{F}{\hbar} \frac{dE}{dk} dt$$

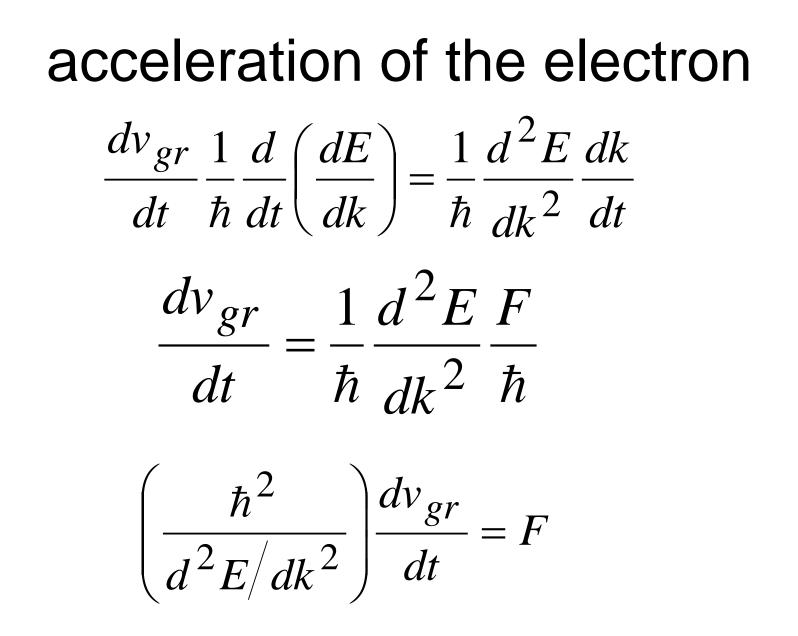
### energy

This work provides an increment of the energy of the electron in the crystal; dA = dE. Taking into account dE = (dE/dk) dk, we get

$$\frac{dE}{dk}dk = \frac{F}{\hbar}\frac{dE}{dk}dt$$

whence it follows that

$$\frac{dk}{dt} = \frac{F}{\hbar}$$



#### effective mass

$$m\frac{dv}{dt} = F$$

we arrive at the conclusion that the expression

$$m^* = \frac{\hbar^2}{d^2 E/dk^2}$$

plays the part of the mass with respect to the external force. In this connection, the quantity given by (4.45) is called the effective mass of an electron in a crystal.

# Behavior of the effective mass

- Near the bottom of the band (see the points A and A' m\* ≈ m
- At the point of inflection (point *B*) the second derivative of *E* is zero.
  Consequently, *m*\* becomes infinite.
- Near the ceiling of the allowed band (point C), the derivative is d2E/dk2 < 0</li>

