PHY404- Solid State Physics II

Assoc.Prof. Yeşim Moğulkoç

Fermi surfaces and Metals

The Fermi surface is the surface of constant energy E_F in **k** space.

Fermi surface separates the unfilled orbitals from the filled orbitals, at absolute zero. The electrical properties of the metal are determined by the volume and shape of the Fermi surface, because the current is due to changes in the occupancy of states near the Fermi surface.

(The figure is used from Introduction to Solid State Physics, C. Kittel)

Reduced zone scheme

It is always possible to select the wavevector index **k** of any Bloch function to lie within the first Brillouin zone. The proceduce is known as mapping the band in the reduced zone scheme.

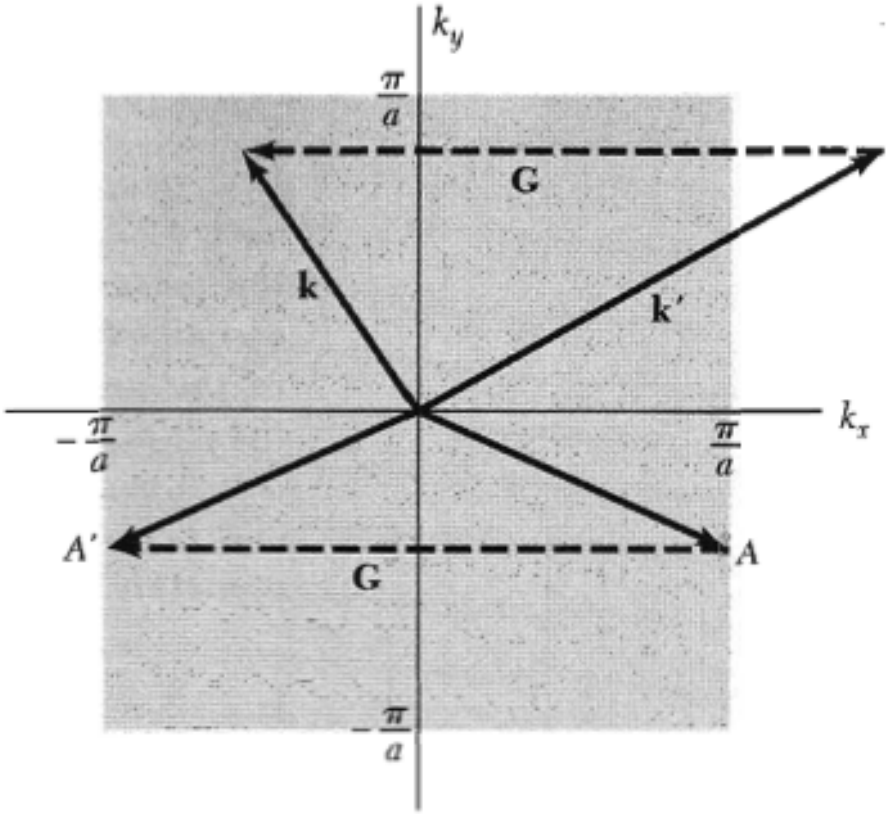
$$\psi_{\mathbf{k}'}(\mathbf{r}) = e^{i\mathbf{k}'\cdot\mathbf{r}} u_{\mathbf{k}'}(\mathbf{r}) = e^{i\mathbf{k}\cdot\mathbf{r}}(e^{\ i\mathbf{G}\cdot\mathbf{r}} u_{\mathbf{k}'}(\mathbf{r}))$$
$$= e^{i\mathbf{k}\cdot\mathbf{r}} u_{\mathbf{k}}(\mathbf{r}) = \psi_{\mathbf{k}}(\mathbf{r}) \ ,$$

$$\psi_{\mathbf{k}'}(\mathbf{r}) = e^{i\mathbf{k}'\cdot\mathbf{r}} u_{\mathbf{k}'}(\mathbf{r})$$

(The figure is used from Introduction to Solid State Physics, C. Kittel)

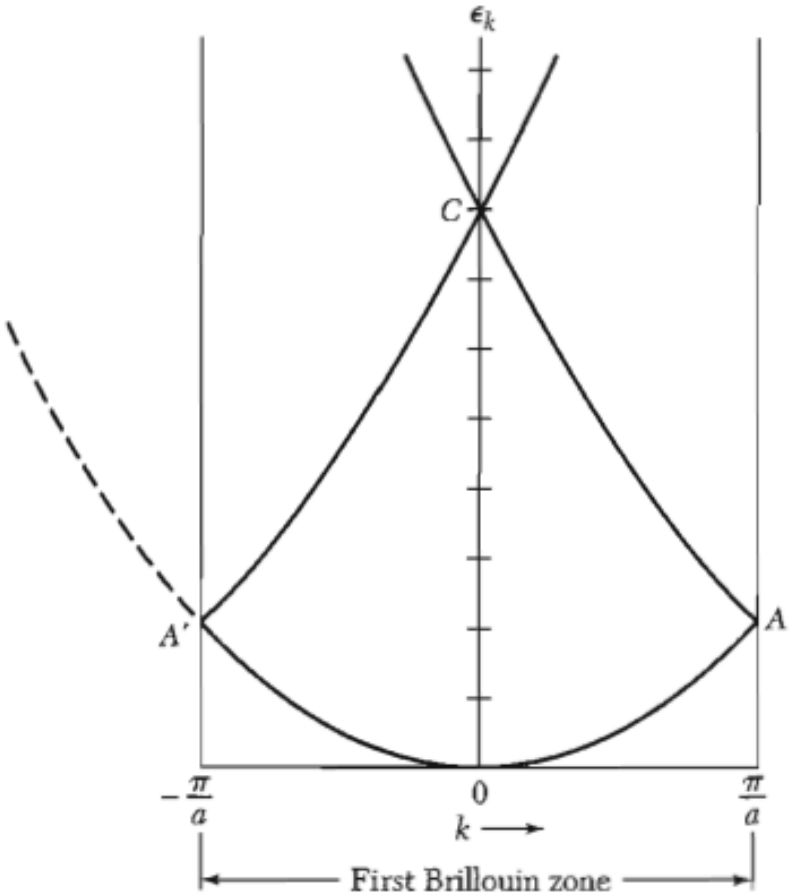
Reduced zone scheme

First Brillouin zone of a square lattice of side ***a .***



(The figure is used from Introduction to Solid State Physics, C. Kittel)

Energy-wavevector relation



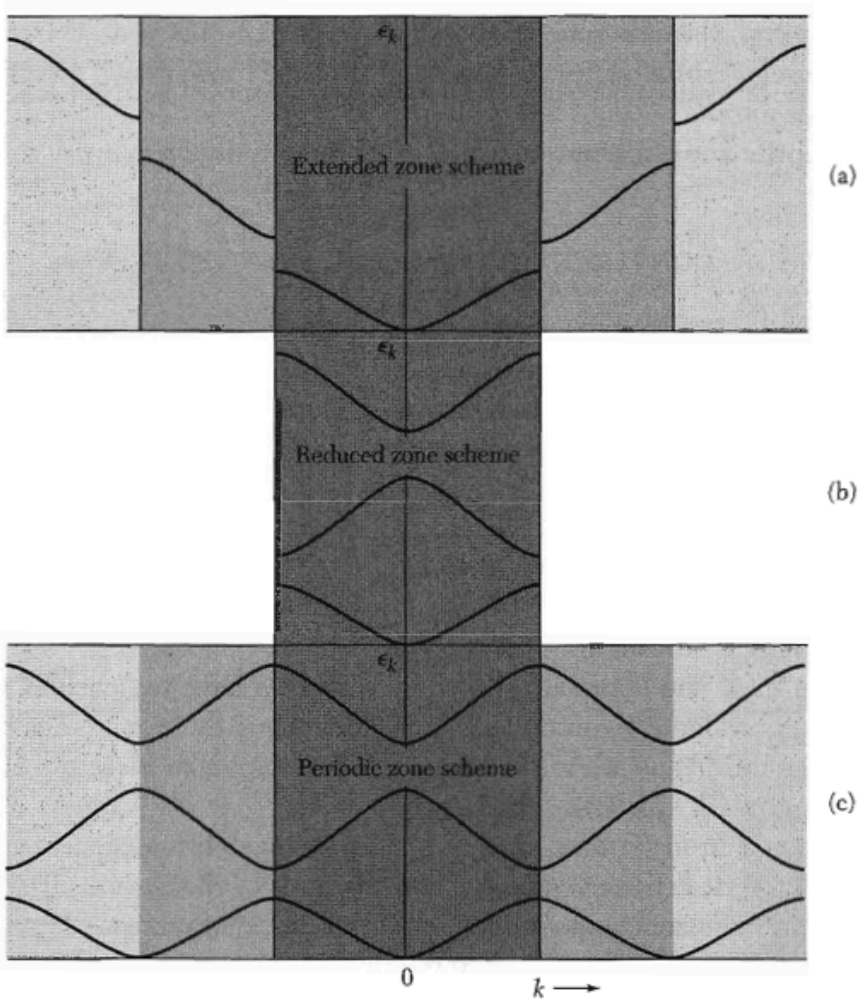
An energy band is a single branch of the $E_{\mathbf{k}}$, versus **k** surface.

In the reduced zone scheme we may find different energies at the same value of the wavevector.

Each different energy characterizes a different band.

(The figure is used from Introduction to Solid State Physics, C. Kittel)

Periodic zone scheme



Three energy bands of a linear lattice plotted in
(a) the extended (Brillouin),
(b) reduced, and
(c) periodic zone schemes

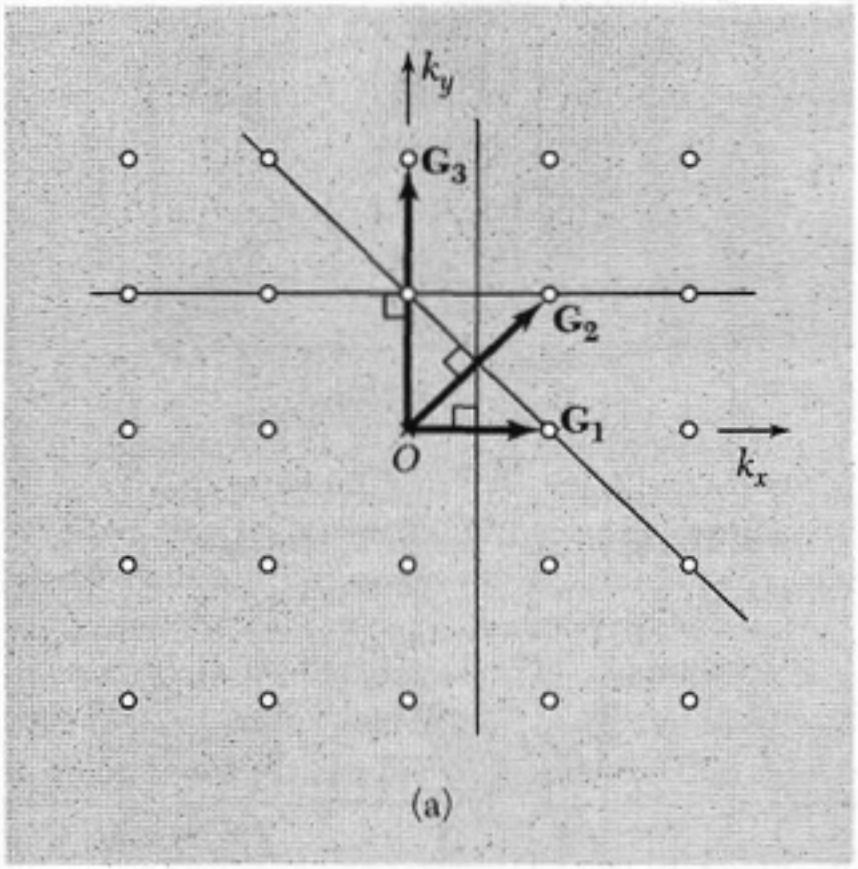
(The figure is used from Introduction to Solid State Physics, C. Kittel)

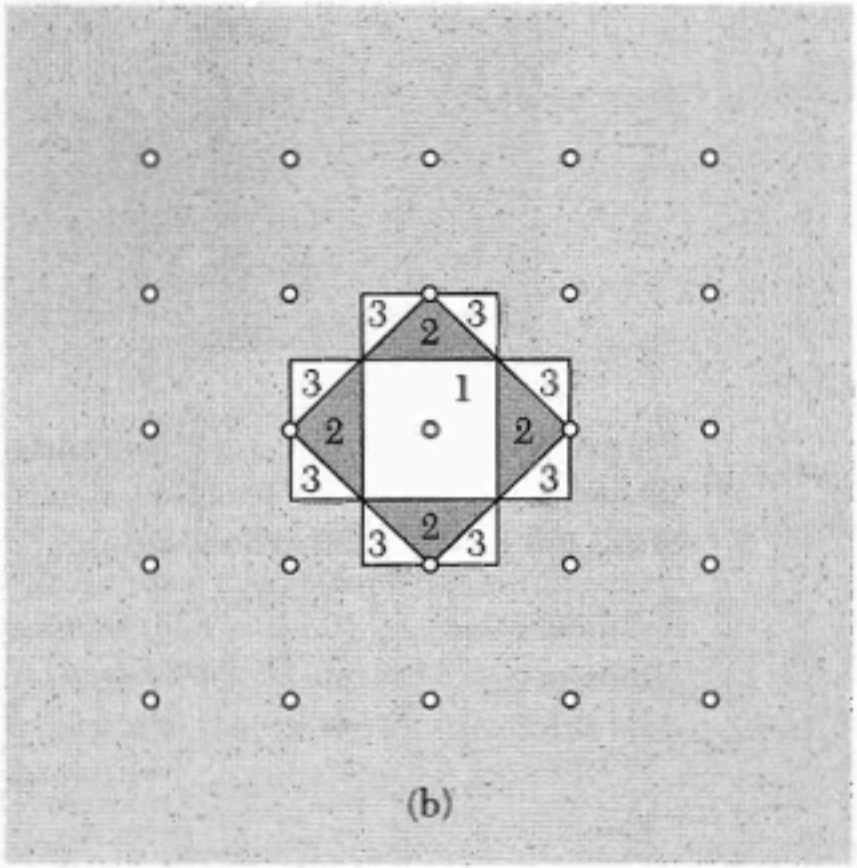
Periodic zone scheme

- The **extended zone scheme** in which different bands are drawn in different zones in wavevector space.
- The **reduced zone scheme** in which all bands are drawn in the first Brillouin zone.
- The **periodic zone scheme** in which every band is drawn in every zone.

(The figure is used from Introduction to Solid State Physics, C. Kittel)

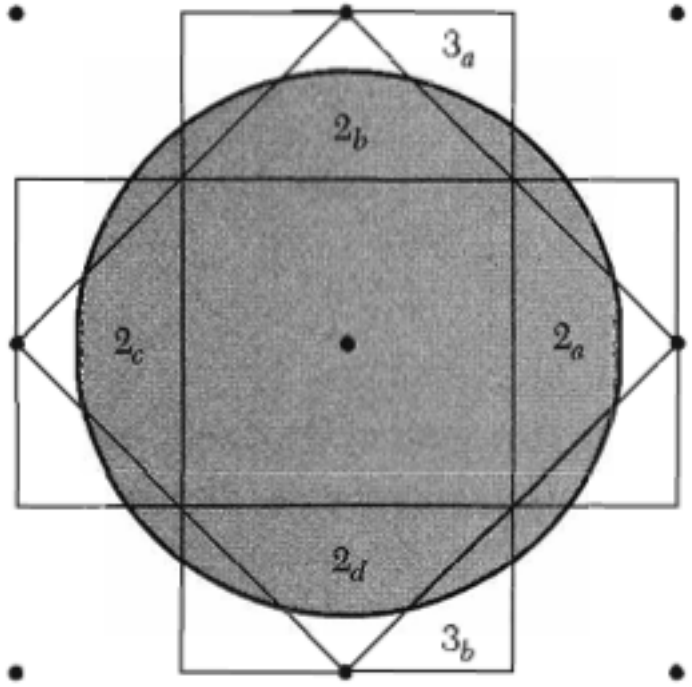
CONSTRUCTION OF FERMI SURFACES





(The figure is used from Introduction to Solid State Physics, C. Kittel)

CONSTRUCTION OF FERMI SURFACES



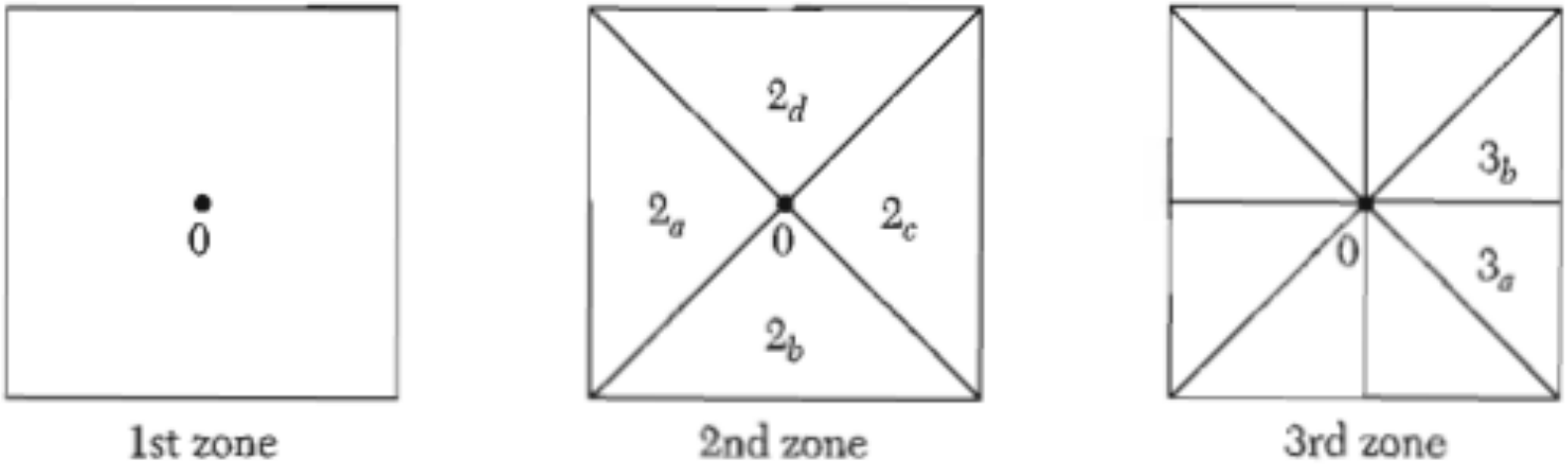
Brillouin zones of a square lattice in two dimensions.

The circle shown is a surface of constant energy for free electrons; it will be the Fermi surface for some particular value of the electron concentration.

(The figure is used from Introduction to Solid State Physics, C. Kittel)

CONSTRUCTION OF FERMI SURFACES

The shape of the Fermi surface depends on the lattice interaction, and the shape will not be an exact circle in an actual lattice



(The figure is used from Introduction to Solid State Physics, C. Kittel)