Universität Bonn 05.12.2003
Physikalisches Institut
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Übungen zur Festkörpertheorie I — WS03/04

4. Übungsblatt

1. Band structure of a 2D surface band

   Above the surface of a metal there often exists a surface band of electrons, i.e. a band of electrons moving in strictly two-dimensional (2D) space parallel to the surface. The precise origin of a surface band will be discussed later in the lecture. Here we want to consider the band structure ε_k.

   On a plain surface, the 2D electrons move almost freely (mass m), since the surface band states are somewhat above the surface and, hence, are decoupled from the periodic potential of the lattice.

   On gold surfaces, there, in addition, is a lattice reconstruction (so-called herring bone reconstruction, Fig. 1) where the surface is modulated in the x direction with the periodic potential shown in Fig. 2,

   $$U(x) = U_0 \Theta(\cos(\pi x/a)) \ , \tag{1}$$

   while the y direction remains translationally invariant.

   a) Calculate the 2D surface band structure ε_k. Distinguish energies $E > U_0$ and $E < U_0$.
   b) Sketch the lines of constant energy on the surface.

2. Electron motion in a herring bone surface band

   We describe the surface band approximately by the band structure

   $$\varepsilon_k = D[1 - cos(2ak_x)] + \frac{(\hbar k_y)^2}{2m} \tag{2}$$

   and apply an electric field $\vec{E} = (E_x, E_y) = const.$.

   Calculate the quasiclassical motion of an electron in this band structure. Sketch the trajectories in the x-y plane.

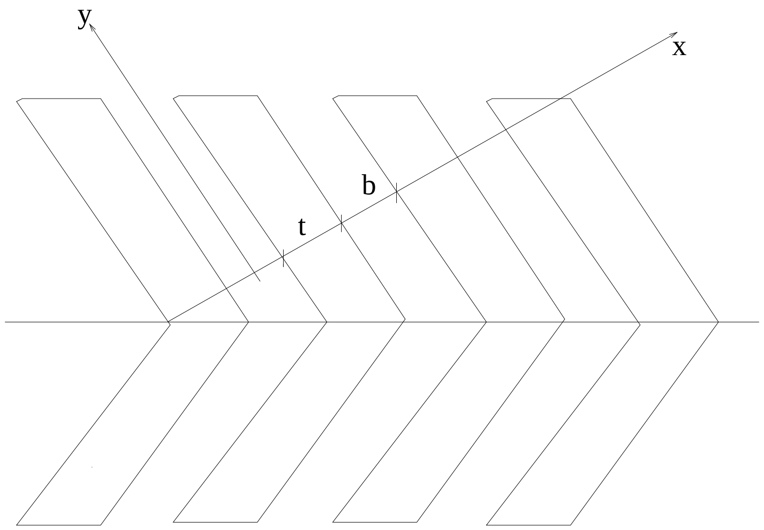

Figure 1: Herring bone reconstruction

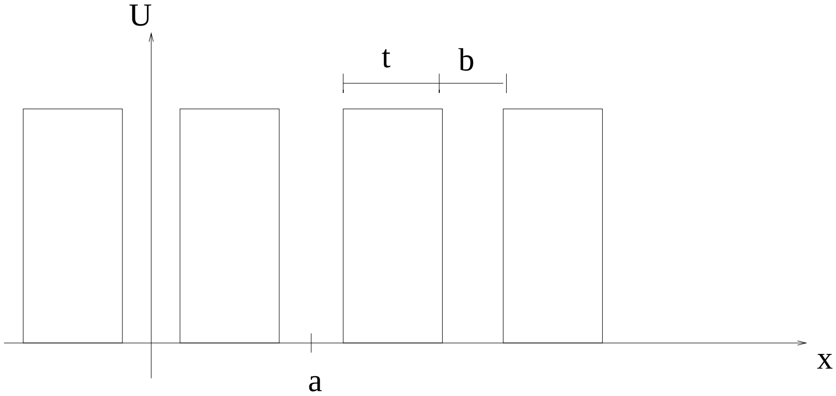

Figure 2: Periodic potential