Übungen zur Oberflächenphysik

Blatt 6 – 15.5.2012

1) Calculate the force and the spring constant between atoms from the Lennard-Jones potential as a function of distance:

$$V = 4\varepsilon\left(\left(\frac{\sigma}{r}\right)^{12} - \left(\frac{\sigma}{r}\right)^{6}\right)$$

Use ε = 0.4eV, σ = 3Å and calculate the equilibrium distance r_k. Compare with the Morse potential:

$$V = U_0\left(\exp\left(-\frac{2(r-s_0)}{\lambda}\right) - 2\exp\left(-\frac{(r-s_0)}{\lambda}\right)\right)$$

U_0=2eV, λ=2 Å.

2) Based on the forces of the Lennard-Jones potential in 1):
   a) Discuss the forces that act during an AFM experiment in a vacuum between the tip and sample.
   b) Discuss what effects (additional forces) may occur when the AFM experiment is carried out in the air, a solution, ….

3) Derive the formula for the force measured by Kelvin Probe Force Microscopy between the AFM tip and sample surface. The energy of the capacitor is $E = (1/2)CV^2$. What is the breakdown voltage limit for the capacitor made by the AFM tip and the sample surface in the air and in the UHV.

4) A silicon cantilever used in a non-contact AFM has a spring constant k = 50 N/m and a mechanical resonance frequency f_0 = 175 kHz. Estimate the mass of the cantilever.

5) A cantilever with a force constant of 0.1 N/m is scanned across a surface in constant height mode. What will be the change in force as it passes over a bump of height 100 nm?

6) In contrast to STM, the AFM is also sensitive to long range forces.
   a) Determine the van der Waals and the electrostatic forces of a sphere (radius r = 10 mm, Hamaker constant $H = 10^{-19}$ J, distance between tip and sample 0.5 nm, potential U = 1 V).
   b) Calculate the corresponding frequency shifts.