Übungen zur **Physik der weichen Materie** , **Serie 2**, FS 2021

Besprechung am 23.03.21

Aufgaben

1. **Beam bending**

   a) Assume that an actin strand is a beam with a square cross-section (side-length 8 nm) and having a length of 100 μm. The elastic modulus is roughly $E = 1.0(1)$ GPa and the yield strength is about $\sigma_Y = 500(50)MPa$. The micro-tubulus is fixed at one end andbent with a force F at the other end. What is the maximum force allowed without breaking the micro-tubulus? Where would it break in this case?

   b) Now compare this to a model of a micro-tubulus, where we assume everything to be the same except that we model it as a hollow beam with an external side length of 25 nm and a wall thickness of 4 nm. What is the maximum force in this case?

2. **Diffusion and Brownian motion**

   You have studied the Brownian motion of fat droplets in milk using a microscope. In the course of this study, you have followed one individual droplet with a radius of $r = 0.40(4)\mu m$ during 10 to 15 minutes. Every 2.0(1) seconds, you have determined its position for 400 consecutive time points. From these you have determined a histogram of the changes in position between consecutive time steps, which you have observed and obtained the following result:

$\Delta x(\mu m)$	N
-0.5 to 0.5	117
0.5 to 1.5	84
-0.5 to -1.5	92
1.5 to 2.5	46
-1.5 to -2.5	32
2.5 to 3.5	8
-2.5 to -3.5	15
3.5 to 4.5	3
-3.5 to -4.5	2
4.5 to 5.5	0
-4.5 to -5.5	1

   a) Plot a histogram of these data and determine $\langle \Delta x \rangle$, i.e. the mean distance travelled in 2 s, as well as $\langle \Delta x^2 \rangle$, i.e. the mean square displacement. Determine the diffusivity of the droplet from these quantities.

   b) Use the Einstein relation to determine the Botzmann-constant from your measurements. Since the fat droplet essentially diffuses in water, use the viscosity of water, $\eta = 1.00(5) \cdot 10^{-3} Pa \cdot s$. Also, te experiment was done at room temperature, i.e. $T = 300(3)K$.

   c) What is the uncertainty of the Botzmann-constant you have thus determined? Compare the value and uncertainty to the literature value.

3. **Diffusion and Random Walks**

   a) Solve the diffusion equation in one dimension: $\frac{\partial c}{\partial t} = D \frac{\partial^2 c}{\partial x^2}$. Use as a boundary condition that the concentration at $t = 0$ is a delta function at $x = 0$.

   b) What is the radius of gyration of a Gaussian chain consisting of N elements of length ξ?

4. **Entropic forces**

   a) Can you think of the force needed to compress a gas as an entropic force? How would you make such a description quantitative?

   b) Determine the spring constant of rubber. What materials parameters do you need for this?

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