

Advanced statistical physics

Homework 2

first appeared on 8.4.2020, due 27.4.2020 by email to juraj.tekel@gmail.com

feel free to hand in solutions in slovak

Problem 1 (Ups). Measurement of mass of a particle has given a result $(-0.3 \pm 1)eV$. This is clearly wrong since the mass has to be positive. What is the corrected result for the mass of the particle after taking this into consideration?

Problem 2 (Canonical ensemble as density matrix.). The canonical ensemble can be viewed as a density matrix

$$\rho = \frac{1}{Z} e^{-\beta H} = \frac{1}{Z} \sum_n |n\rangle e^{-\beta E_n} \langle n| .$$

Using the expression for the entropy

$$S = -k \text{Tr}(\rho \log \rho)$$

show that $S = (E - F)/T$.

Problem 3 (Density of states.). What is the density of states for classical and ultra-relativistic particles in 2 and 1 dimensions?

Problem 4 (Air-hockey equation of state.). What is the equation of state for the two dimensional system of hard pucks of radius R in a box of size $L \times L$, which takes into account first non-trivial contribution of their interaction?

Problem 5 (Bonus. Hyper-hockey equation of state.). What is the equation of state four dimensional system of hard 4-spheres of radius R and a constant potential $-V_0$ when separated by less than xR in a box of size L^4 , which takes into account first non-trivial contribution of their interaction?