Problem Sheet 7

for the lecture "Statistical Physics", Master course "Computational Science", year 2007/08

due date: Tuesday, December 18, 2007

Problem 1 5 points

Let $U = \sum_j n_j \hbar\omega_j$ be the energy of a photon gas where n_j is the occupation number of the j-th mode. Find an expression for the pressure exerted by this gas, as a function of the energy U itself. This pressure is called the gas radiation pressure. Hint: express the mode frequency as a function of the occupied volume.

Problem 2 5 points

Consider a one-dimensional gas of N particles, each of mass m, confined to a one-dimensional line of length L. Find the entropy at temperature τ. The particles should be treated as classical objects.

Problem 3 5 points

As you know, the energy levels of a quantum mechanical harmonic oscillator are given by $E_n = \hbar\omega(n + \frac{1}{2})$, $n = 0, 1, 2, \ldots$. Calculate the probabilities of finding this oscillator in an *even* state (i.e., n even) and in an *odd* state (i.e., n odd).

Problem 4 5 points

- Compute the average number of photons N in a photon gas at a given temperature and volume. Hint: $\int_0^\infty \frac{x^2}{e^x - 1} dx = A \simeq 2.404$.
- Express energy, pressure, and entropy of the photon gas as a function of T, N, and V.
- Compare the above quantities with the ones of a ideal classical gas and point out differences and similarities.