

Exercises in Statistical Mechanics

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This exercises pool is intended for a graduate course in “statistical mechanics”. Some of the problems are original, while other were assembled from various undocumented sources. In particular some problems originate from exams that were written by B. Horovitz (BGU), S. Fishman (Technion), and D. Cohen (BGU).

===== [Exercise 2230]

Harmonic oscillators, Photons

Find the state equations of photon gas in 1D/2D/3D cavity within the framework of the canonical formalism, regarding the electromagnetic modes as a collection of harmonic oscillators. The volume of the cavity is L^d with $d = 1, 2, 3$. The temperature is T .

- (1) Write the partition function for a single mode ω .
- (2) Find the mode average occupation $f(\omega)$.
- (3) Find the spectral density of modes $g(\omega)$.
- (4) Find the energy $E(T)$ of the photon gas.
- (5) Find the free energy $F(T)$ of the photon gas.
- (6) Find an expression for the pressure $P(T)$ of the photon gas.

Note: additional exercises on photon gas and blackbody radiation can be found in the context of quantum gases. Formally, photon gas is like Bose gas with chemical potential $\mu = 0$. Note that the same type of calculation appears in Debye model (“acoustic” phonons instead of “transverse” photons).