PHYSICS 140B : STATISTICAL PHYSICS
HW ASSIGNMENT #1

(1) For the Dieterici equation of state,

$$p(V - Nb) = Nk_{\mathrm{B}}T\, e^{-Na/Vk_{\mathrm{B}}T}\ ,$$

find the virial coefficients $B_2(T)$ and $B_3(T)$.

(2) Consider a gas of particles with dispersion $\varepsilon(\boldsymbol{k}) = \varepsilon_0\,|\boldsymbol{k}\ell|^{5/2}$, where ε_0 is an energy scale and ℓ is a length scale. Find the density of states $g(\varepsilon)$ in $d = 2$ and $d = 3$ dimensions.

(3) For the dispersion $\varepsilon(\boldsymbol{k}) = A\,|\boldsymbol{k}|^4$ obtain expressions for the second virial coefficient $B_2(T)$ for the Bose-Einstein and Fermi-Dirac cases. Assume $d = 3$ dimensions.

(4) A gas of quantum particles with photon statistics in $d = 3$ dimensions has dispersion $\varepsilon(\boldsymbol{k}) = A\,|\boldsymbol{k}|^{3/2}$.

   (a) Find the single particle density of states per unit volume $g(\varepsilon)$.

   (b) Repeat the arguments of §5.5.2 in the lecture notes for this dispersion.

   (c) Assuming our known values for the surface temperature of the sun, the radius of the earth-sun orbit, and the radius of the earth, what would you expect the surface temperature of the earth to be if the sun radiated particles with this dispersion instead of photons? (Hint: study §5.5.5 of the lecture notes.)