

PHYSICS 140A : STATISTICAL PHYSICS
HW ASSIGNMENT #9

- (1) For a system of noninteracting $S = 0$ bosons obeying the dispersion $\varepsilon(\mathbf{k}) = \hbar v|\mathbf{k}|$.
- (a) Find the density of states per unit volume $g(\varepsilon)$.
 - (b) Determine the critical temperature for Bose-Einstein condensation in three dimensions.
 - (c) Find the condensate fraction n_0/n for $T < T_c$.
 - (d) For this dispersion, is there a finite transition temperature in $d = 2$ dimensions? If not, explain why. If so, compute $T_c^{(d=2)}$.
- (2) Using the argument we used in class and in §5.4.2 of the notes, predict the surface temperatures of the remaining planets in our solar system. In each case, compare your answers with the most reliable source you can find. In cases where there are discrepancies, try to come up with a convincing excuse.
- (3) Read carefully the new and improved §5.5.4 of the lecture notes (“Melting and the Lindemann criterion”). Using the data in Table 5.1, and looking up the atomic mass and lattice constant of tantalum (Ta), find the temperature T_L where the Lindemann criterion predicts Ta should melt.
- (4) For ideal Fermi gases in $d = 1, 2,$ and 3 dimensions, compute at $T = 0$ the average fermion velocity.
- (5) Consider a three-dimensional Fermi gas of $S = \frac{1}{2}$ particles obeying the dispersion relation $\varepsilon(\mathbf{k}) = A|\mathbf{k}|^4$.
- (a) Compute the density of states $g(\varepsilon)$.
 - (b) Compute the molar heat capacity.
 - (c) Compute the lowest order nontrivial temperature dependence for $\mu(T)$ at low temperatures. *I.e.* compute the $\mathcal{O}(T^2)$ term in $\mu(T)$.