Problem set for chapter 4, Due Wed. Feb. 1

Useful references for this problem set include:

- Callaway, chapter 1.
- Ashcroft & Mermin, chapter 22.

1. Argon is a Van der Waals FCC crystal, for which the pair potential is of the Lennard-Jones type:

$$V(r) = 4\epsilon \left[\left(\frac{\sigma}{r}\right)^{12} - \left(\frac{\sigma}{r}\right)^{6} , \right]$$

where $\epsilon = 1.05 \times 10^{-2}$ eV and $\sigma = 3.4\mathring{A}$. Neglecting all be nearest-neighbor forces, calculate the dispersion $\omega(\mathbf{k})$ for the longitudinal phonons in the (1,0,0) direction.

2. Read about the theory of elasticity in Ashcroft and Mermin. Then, consider a crystal of Ag, and look up its atomic mass and elastic constants.

- Obtain an expression, in terms of the lattice frequency spectrum, for the mean-squared excursion $|\mathbf{s}(0)|^2$ of a crystal atom about its equilibrium position.
- Look up the atomic mass, elastic constants, and melting temperature T_M of Ag, and estimate $|\mathbf{s}(0)|^2$ at $T = 0$ and $T = T_M$.

3. Calculate the dispersion of a simple linear chain of atoms each of mass M, bound together with springs of spring constant f. Now, reconsider the example of a diatomic linear chain discussed in Ibach and Lüth Sec. 4.3. Show that when $M = m$ for the latter example, the two results are consistent (hint remember that when $M = m$ that the principle translation distance halves).