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 \( \sigma = 3.4\text{Å} \). Neglecting all be nearest-neighbor forces, calculate the dispersion \( \omega(k) \) 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 \( |s(0)|^2 \) of a crystal atom about its equilibrium position.
   
   - Look up the atomic mass, elastic constants, and melting temperature \( T_M \) of Ag, and estimate \( |s(0)|^2 \) 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).