

Physics 240B: Homework Problem Set 4

Due: February 7, 2008

1. Lattice Stiffness of Elemental Solids. 35 points.

For this problem, use the Debye temperatures θ_D given in Table 13.1 of Marder. Note that Tc (technetium) is missing; all of its isotopes are highly radioactive and there is relatively little data for Tc and its compounds. Here (to produce connected plots) use the average of θ_D for the neighboring elements, Mo and Ru.

(i) Plot θ_D for each of the $3d$ (Sc-Ni), $4d$ (Y-Pd) and $5d$ (La-Pt) series, versus the position in the series (1,2,3,...). Put all three lines (one for each series) on the same plot. Describe the behavior (as if explaining in a publication, or in a classroom).

(ii) There is a “trivial” mass dependence in θ_D , so now plot again the value of $M\theta_D$, where M is the mass of the atom. It is common to use the average mass of the isotopes, as weighted by their natural occurrences; this is the mass commonly listed in Periodic Tables. The plots now give a measure of the lattice stiffness \mathcal{K} , which in a near-neighbor force constant model would just be the spring constant. In reality it is more involved: these are metals with forces between several neighbors. Characterize in words the behavior you obtain.

2. Stiffness of Monovalent Metals. 25 points.

Plot, as in Problem 1, θ_D for the two columns of monovalent metals: the alkalis Li, Na, K, Rb, Cs, and the noble metals Cu, Ag, Au.

(i) Plot these on the same plot with separate curves for each column.

(ii) Then replot as $\mathcal{K} = M\theta_D$ to eliminate the mass dependence.

In each case describe what is reasonable, or perhaps unexpected, about the behavior.