PHYS 3317: Van der Waals force

Tuesday Oct 21, 2014

Hand in at beginning of next lecture

Problem 1. A polarizable atom

1.1. While there are more generic pictures, a nice concrete model of a polarizable atom/molecule is a positive and negative charge bound by a spring whose equilibrium length is zero. It will have zero electric dipole moment in equilibrium, but if you put it in an electric field, the positive and negative charge will be pulled apart. Come up with a model (or even just an argument) for what the energy is as a function of separation d of the two charges in a field of strength E. Don't worry about factors of 2, etc.

Solution 1.1.

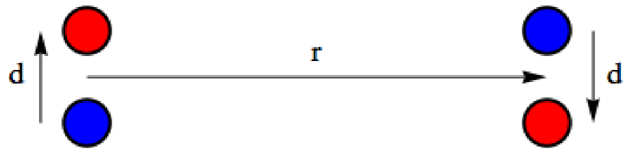
Problem 2. Field from a dipole

2.1. What is the strength of the electric field a distance r from the dipole. (Just give the field from the two charges, don't include the background field which polarized the molecule.) The electric field is clearly anisotropic – I don't care about the anisotropy, nor multiplicative constants just how its strength varies with r. [Hint – you know the field from a single charge. The expression for the sum of the fields from the two charges should look similar to a derivative.]

Solution 2.1.

Problem 3. Two polarizable atoms

3.1. Now consider the case of two atoms separated by a distance r. Use the previous model for each atom. Suppose, as illustrated here, they each are polarized in opposite directions. What is the energy as a function of d for fixed r. [This should end up looking like a harmonic oscillator.



Solution 3.1.

3.2. Now consider the case where the polarizations are in the same direction. What now is the energy as a function of d for fixed r. [This should end up looking like a harmonic oscillator, with the energy proportional to d^2.]

Solution 3.2.

3.3. Add the zero point energy from each of these fluctuations to get an interatomic potential $V(r)$. [Again, don't worry about factors of 2, etc.] Assume $d \ll r$.

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