INDUCTION FORCES AND DISPERSION FORCE

We have seen that charges and regions of relative charge difference can interact to attract and/or repel one another. How does a non-charged, non-polar atom or molecule interact with a dipole? It turns out that a dipole can **induce** a dipole moment in, say, an atom. Take a look at the animation below.

← This animation simulates the distortion of the electron cloud of a neutral atom as a polar molecule (e.g. HCl) is brought near.

An atom is spherically symmetric, so it can't have a *permanent* dipole moment. But the distortion of its electrons away from its nucleus under the influence of the approaching dipole destroys that symmetry and gives the atom a small dipole moment of its own.

The **induced dipole** interacts with the permanent dipole just as a permanent one would, induced dipoles are just weaker, so any attraction or repulsion is weaker. Any polar molecule can similarly rearrange the electron cloud of any molecule, including molecules that already have permanent dipole moments.

In fact, the induction force accounts for about 10% of the total cohesive binding force of liquid water - the force that accounts for the beading of water on a surface, the first image of this section.

Dispersion Force

The **dispersion force**, also known as **London dispersion**, is a purely **quantum-mechanical** force, and can only be truly understood by applying the laws (and mathematics) of **quantum mechanics** to the outer electrons of atoms.

It goes something like this: Think about two inert-gas atoms sitting side by side. From time to time in an atom the electron density is momentarily unbalanced, momentarily spoiling the spherical symmetry and forming a small dipole. This moment can induce a similar fluctuation in the other atom, and so on. Such fluctuations can become **correlated** (they occur more or less in synch.), producing an overall attraction between atoms that we might otherwise think would have no mechanism of attraction. That's roughly what the dispersion force is.

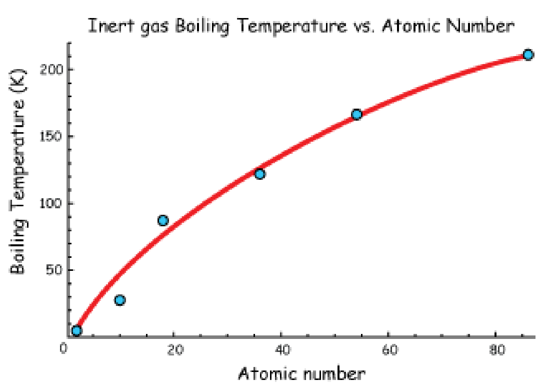
← This animation illustrates how such a correlation of electron-cloud asymmetry might look. It's highly stylized, just a cartoon. A little funny really, atoms doing a jiggle dance.

The dispersion force scales roughly with the number of electrons for atoms, and similarly for molecules—the bigger the atoms the larger the attractive dispersion force.

We know that the dispersion force is real by looking at the properties of inert gases, where the only *possible* intermolecular force is dispersion.

This graph shows that helium (He), with only two electrons, has a much lower boiling point (the temperature at which atoms are liberated from the liquid) than larger inert gas atoms like Krypton (Kr) and Xenon (Xe). As the dispersion force becomes larger, it takes more energy to liberate an inert gas atom from the liquid because it is stuck to its neighbors more strongly.

Note that the dispersion attraction doesn't scale exactly with the atomic number - the graph is not linear. That means that dispersion must scale with more than just the number of electrons.



Source: http://www.drcruzan.com/IntermolecularForces.html