2.5: E- Molecular Interactions - Fluctuating Dipole Interactions (Dispersive Interactions, London Forces)

We can see resonance all around us. A child on a swing, the tides in the Bay of Fundy and the strings on a violin all illustrate the natural resonant frequencies of physical systems. The Tacoma Narrows Bridge is one of the most famous examples of resonance.

Molecules resonate too. Electrons, even in a spherical atom like Helium or Xenon, fluctuate over time according to the natural resonant frequency of that atom. Even though chemists describe atoms like Helium and Xenon as spherical, if you could take a truly instantaneous snapshot of a spherical atom, you would always catch it in a transient non-spherical state. Xenon is spherical on average, but not at any instantaneous timepoint.

As electron density fluctuates, dipole moments also fluctuate. Therefore, all molecules and atoms contain oscillating dipoles. In all molecules that are close together (in any liquid or a solid, but not in a perfect gas) the oscillating dipoles sense each other and couple. They oscillate in synchrony, like the strings of a violin. The movements of electrons in adjacent molecules are correlated. Electrons in one molecule tend to flee those in the next, because of electrostatic repulsion. Coupled fluctuating dipoles experience favorable electrostatic interaction known as dispersive interactions.
**Figure 13** shows how dispersive interactions in liquid Xenon (or Helium or Neon, etc) are caused by attractive interactions between coupled fluctuations of dipoles. Darker blue indicates higher electron density. The fluctuations are correlated and are very fast, on the femtosecond ($10^{-15}$ second) timescale. Adjacent Xenon atoms experience electrostatic attraction from the transient dipoles. Two different representations of fluctuating dipoles are shown.

Dispersive interactions are always attractive and occur between any pair of molecules, polar or non-polar, that are nearby to each other. Dispersive interactions are the only attractive forces between atoms in liquid He (bp 4.5 K), Ne (27K), Ar (87K) and between molecules of N$_2$ (77K). Without dispersive interactions there would be no liquid state for the Nobles.

The total number of pairwise atom-atom dispersive interactions within a folded protein is enormous, so that dispersive interactions can make large contributions to stability. The strength of this interaction is related to polarizability. Tryptophan, tyrosine, phenylalanine and histidine are the most polarizable amino acid sidechains, and form the strongest dispersive interactions in proteins.

*What about water?* Even molecules with permanent dipoles, like water, experience dispersive interactions. About a 25% of the attractive forces between water molecules in the liquid are dispersive in nature.

Dispersive interactions fall off with $1/r^6$. 

---

https://bio.libretexts.org/Bookshelves/Biochemistry/Book%3A_Macromolecular_Structure_Proteins_and_Nucleic_Acids_(Willi…

Updated: Thu, 02 Jul 2020 09:45:29 GMT

Powered by